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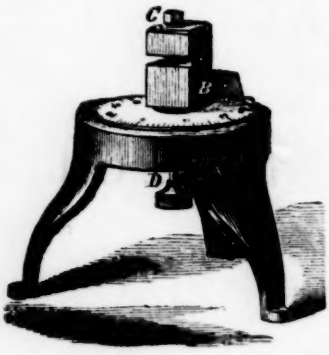
EDITORIAL.

ITEMS AND NOVELTIES.

A Sheet Metal Gauge, made by J. R. Brown & Sharpe, Providence, R. I., was exhibited at the last meeting of the Franklin Institute.

The difficulty of measuring the thickness of sheet metals with accuracy is well known to all persons who have occasion to use or deal in them. The gauges commonly used having a series of fixed sizes determine the thickness only approximately, and, as the sizes wear by constant use, such gauges become still more unreliable. The edges of sheet metal being often imperfect, ordinary gauges are prevented from going on readily. It usually happens that the edges are thinner than the middle of the sheet, and the gauge

cannot reach on far enough to measure the thickest part. In selecting sheet metals for many purposes, it is desirable to have a gauge to indicate the exact thickness in parts of an inch. To accomplish this result, the gauge shown in the engraving has been devised, which will give the thickness of a piece of metal up to one-quarter of an inch in thousandths of an inch, and at some distance from the edge of the sheet. The stand, A, supported upon three feet, with an upright, B, is a single casting. In this upright is a space or slot. Above this space, in the upright, is an adjusting screw, C. Fitted into the lower part of the upright is a screw, D, with a milled head on the lower end. Attached to this screw, and revolvingwith it, is a German-silver dial. The graduations on the edge of this dial are read off from an index point. The upper and lower screws are exactly in line with each other, and their points, which are hardened, meet in the space between the two. The threads upon the screw, D, are ten to one inch, and the edge of the dial is divided into one hundred parts. With this explanation of the position and relation of the several parts of the gauge, it will readily be perceived that when the metal to be measured is placed in the opening in the standard, and the screw, D, made to revolve until the metal is held between the ends of the screws, D, and the adjusting screw, then the exact thickness can be read off in thousandths of an inch at the index point. Should any wear of the points of the screws take place the point, 0, can always be kept exactly opposite the index point by means of the adjusting screw. A small binding screw, with a piece of brass under its point, serves to hold the adjusting screw firmly in its place, when it is set correctly. The accuracy and simplicity of this gauge will commend it to those who desire to obtain uniformity in the thickness of sheet metals, or in thin materials of any kind. It is particularly useful to machinists, jewelers, silversmiths, sheet-brass rollers and workers, sheet-iron rollers, rubber manufacturers, paper makers, and type founders.

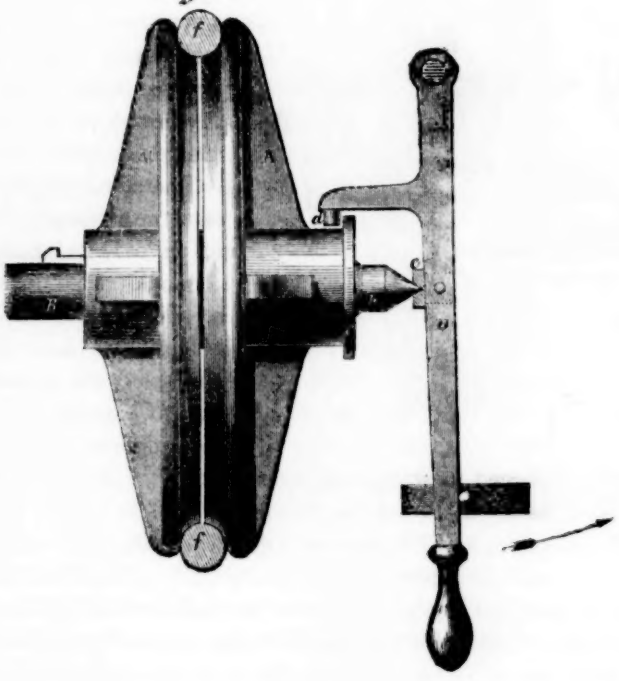


These gauges may be seen at the store of J. W. Queen & Co., 924 Chestnut street.

Improved Clutch Pulley, by John Shinn, of Philadelphia. In this apparatus, the object is to shift a belt from a loose to a fast pulley, with greater advantage, in many respects, than can be secured by the usual arrangement. We will first describe the apparatus, and then allude to its special claims to distinction.

Two pulleys are arranged, as shown in the cuts at A and A′; both

Fig. 1

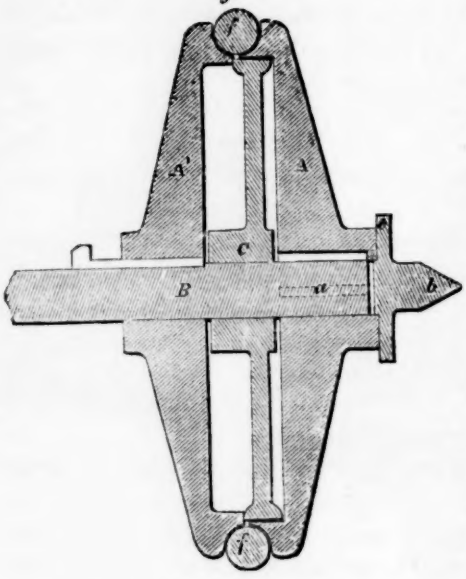


of these are fast pulleys, but while one A′ is keyed to the shaft B, the other, A, slides on a feather, by which means, its distance from A′ may be varied, and any desired amount of bite obtained upon the cord between their edges. The middle wheel, C, constitutes the loose pulley of this system, and the band comes upon this when the pulley A is caused to recede from A′, so as to let the cord come down between them.

These motions of the pulley A are secured by means of the lever D, which bears upon the steel centre, *b*, of the wheel A, thus bring-

ing the pulleys A′ and A together; and the pin and friction roller, *d*, bearing on the collar, *c*, by which the latter pulley is withdrawn from the other. Where it is desirable to bring the bite or grasp of the pulley upon the cord to a certain point, and there regulate it, the pressure is brought upon the wheel by a set-screw, with jam nut, attached to the lever, D, and bearing upon a depression in the plate, *e*, the steel centre, *b*, being removed.

Fig 2



The advantage of such an arrangement in the case of delicate machinery, is obvious. The tension is so adjusted that the hold of the cord is just sufficient to drive the apparatus; if, then, any derangement occurs by which the machinery if forced forward might be broken, the increased resistance makes the band slip, and no harm is done.

Thus, for example, in dying cotton warps, the yarn sometimes laps on the rollers under the dark colored solution in the vats, where it is therefore invisible, and before the mischief is discovered, a great quantity of valuable material may be destroyed.

We have heard of cases where $300 worth of yarn has thus been lost in a single day.

It is not proposed, of course, to drive very large and heavy machinery with round belts, such as are required for this description of shifting pulleys, but as far as a round belt will go with advantage (and this is very far), these pulleys will be found of the greatest service.

Thus, the round belt cuts off less light, occupies less room, makes smaller holes in the floors, requires lighter driving pulleys to carry it, and thus saves power; while as regards the driving power of round belts, we have seen one of an inch diameter, doing for years, work which proved too much for a seven-inch flat belt.

The Brooks Insulator in France.—In our issue of last July, we gave some account of the admirable improvement in telegraph insulators made by Mr. David Brooks, and we published the result of experiments made upon them, in comparison with others, by Dr. Charles M. Cresson. Since that time, the insulator, without a preliminary decease, has been, where other good Americans are reported to go after that event—to Paris.

We have now received the first news of its arrival and condition, from the French press. In *L'Union*, of February 4th, we find the following statements, which it gives us great pleasure to translate and publish.

"M. de Vougy, Director-General of Telegraphs, some time since appointed a commission specially charged with the examination of telegraph insulators of the most approved construction, with a view to the adoption of the best sort for our lines.

"This commission, provided with instruments of the greatest delicacy for detecting loss of the current by the insulators, have established the great superiority of the insulator devised by Mr. David Brooks, of Philadelphia, to all its competitors, and have ordered from him a large number to make an experiment, on the large scale, upon our telegraph lines." A description is here given, which we omit, because identical in substance with that we have already published, (Vol. IV., p. 10,) after which, as follows:

"Mr. Brooks, who is constantly engaged in connection with telegraphic constructions, and whose insulator is very well known in America, only arrived at the complete form, which we have just described, after many and continued experiments.

"It is clearly to the use of paraffine, long recognized as the first of insulating substances, that Mr. Brooks owes the success which he has obtained."

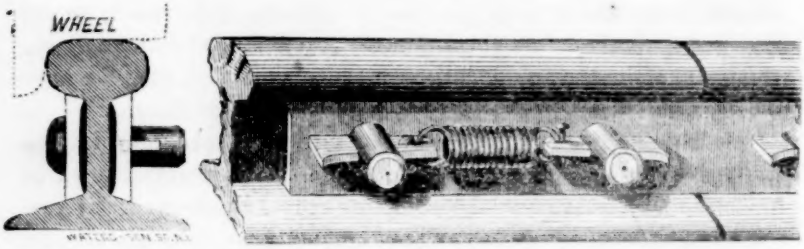
We may add, however, to this last, that though the insulating power of paraffine has been long known, its peculiar property of repelling moisture (to which its efficiency in this special application is mainly due,) has only been brought into notice by this very application made by Mr. Brooks.

From a private letter received from a gentleman who is one of the commission mentioned above, we learn that, in the actual trials referred to, the Brooks Insulator *excelled its next best rival fully one hundred times.*

A Self-Tightening Steel Attachment for railway joints, was exhibited at the last meeting of the Institute, by the Knox Railway

Clamp Company. This apparatus consists of two steel keys, a spring and two iron retaining pins, which, added to the bolts and plates, complete the *clamp*. The bolts, instead of being held by the usual thread and nut, are punched with smooth key-holes, and secured by tapering keys, the small ends of which are connected by a spiral spring, and made fast by the retaining pins, to prevent either the spring or keys being removing without proper tools, thereby making the fastening doubly secure. This spring is continually drawing the keys in, and tightening up the plates as fast as any wearing occurs between them and the rails, so that the working of the latter, by expansion or sliding, must necessarily wear off all scales and roughness.

The whole joint, eventually, becomes as perfectly fitted as the piston to an engine, so there is no possibility of the end of one rail being forced higher or lower than the other, thereby making a practically continuous track with a solid rail, and entirely doing away with the noise, so annoying to passengers, and saving thousands of dollars annually in rails, ties, engines, &c.



It is claimed that until the Knox Clamp was introduced, there has been no chair or joint made that has the self-perfecting feature of working tight, but, on the contrary, all get looser as they become worn. This arrangement is entirely independent of that for expansion and contraction, which is provided for by the elongated holes through the rails, so that each clamp allows for the expansion of its respective rail only, and is much safer than the ordinary lip-chair, which does not prevent the rails from sliding along and opening at a single joint from two to four inches, the result, oftentimes, of very serious accidents.

A peculiarity of this clamp is, that it tightens up when a train is passing over, which is the only time a joint is forced to its proper firm position.

One can hardly realize the importance of having a clamp or chair that will continually keep the ends of the two rails of the same height, unless he stands by the side of a track and watches a joint when a train is passing over at full speed; then, and only then, can he form any idea as to the force with which a wheel strikes the least projection of a rail, which cause alone has broken more wheels, thrown more trains off the track, destroyed more engines and cars, hammered out more ties, battered up and split more rails, than all other causes combined.

The plates for this clamp are generally punched with one-inch round holes, five inches apart from centre to centre.

Railway engineers have of late paid particular attention to having the rails for fishing made of the same angle and shape, under the shoulder or tread, that it has over the base or web, so the plates will fit exactly, if placed either side up by careless workmen.

These attachments are now being introduced on the Pennsylvania Central, Philadelphia and Reading, Chicago and North-Western Railroads.

Effects of Heat on Infusoria.—A very interesting but elaborate series of experiments on living organisms in heated water, is recorded by Professor Wyman, of Harvard College, in the September No. of Silliman's Journal. As the majority of these experiments are abstruse, entering into very exact descriptions, and noticing very minute differences, a full repetition of them would be tedious to any but those specially engaged in such investigations. We will therefore endeavor to give to our readers the deductions arrived at, and for the record of the experiments the above Journal may be referred to.

In the first place, we would state that there is a controversy existing as to whether the living animalculæ found in fluids are to be traced to "organisms or the germs of them contained in the fluid or in the air."

"Or whether they are to be attributed to the direct transformation of organic matter into new living beings independently of any germs or living organisms whatever," or, in other words, to "spontaneous generation." The object of these experiments is to settle the question whether the process of boiling the solution employed, would or would not destroy organisms or the germs that produce them.

Prof. Wyman has discovered that solutions of organic matter which had been boiled for nearly half an hour, and then exposed only to air which had been passed through red hot tubes, generated

animalculæ. Again, solutions of organic matter were entirely exhausted of air and then hermetically sealed, after which their temperature was raised to the boiling point at periods of time varying from a few minutes to several hours; these also became the seat of infusorial life.

After the solutions had been boiled for a long time, no infusoria appeared. The living infusoria resist in a dry heat a much higher temperature than when moist; as high a heat even as 248° F. according to Doyer, failing to destroy their vitality.

Tubes absolutely empty of Air.—It was for a long time a question of dispute whether the electric spark would pass through an absolute vacuum.

Mr. Gassiot, as is well known, succeeded in constructing an apparatus through which the spark will not pass. He made the vacuum in this apparatus by filling it with carbonic acid and exhausting by the ordinary process. The residue is then slowly absorbed by means of caustic potash. M. M. Alvergniat Brothers, have succeeded in constructing an apparatus in which the same result is obtained in an easier and much more rapid manner. It suffices, in fact, to make the vacuum by means of a mercurial air-pump, which they have contrived. By the aid of this apparatus, one can produce a vacuum almost absolute in the tube intended for experiment, which is provided with two platina wires, placed at a distance of ·08 inches. It takes but half an hour to obtain the requisite tension. At this moment they heat the tube to redness, which must be done by means of charcoal or Bertelot's lamp, for analysis. When the vacuum is so complete that a spark will not pass, we close the communication between the tube and machine.

In a tube thus prepared, notwithstanding the exceedingly small distance between the platina points (·08 of an inch), the spark absolutely ceased to pass.

Editorial Correspondence.

FOREIGN SCIENCE.

PARIS, *February* 2, 1868.

M. POULAIN, formerly Chief Engineer of Bridges and Roadways of Gorea (Senegal), has published a very interesting description of the method employed by him for the drainage of pestilential swamps,

especially with regard to the neighborhood of Hann, where vessels take in their supply of fresh water, and where remarkably rich cultivation could be carried on if one could only live there. Afterwards, he was employed on a topographical mission in Corsica, and he gave an account of the benefits that would arise from the cultivation of the soil, as well as those which would result in a sanitary point of view, in favor of the magnificent harbors that could be established in the island.

The hydraulic department of the above corps has devoted much study to all questions relating to public health and river supplies for industrial purposes. The fertility of the eastern plain of Corsica is well known to the world. Experiments, and, we may say, the history of the land, prove that when this plain is rendered healthy it will be a veritable land of promise for agriculture, &c. Several crops have been grown according to the old method, and the results have proved that the quality of the land and the nature of the climate are of a superior order, also, that the richness of the soil is due to ancient alluvia, produced by the wearing down of the mountains, mingled with the vegetable detritus of centuries. Unfortunately this part of the island is studded with swamps, so that it is fatal to remain there in summer or autumn. To this land the application of M. Poulain's system will be of immense service, in rendering the cultivation profitable in the same manner as has been shown in the Dombe, the Sologne, the Carmagne, and in the Landes of Gascony. By employing Italians, Corsicans and convicts accustomed to the climate, and with proper hygienic precautions, the necessary works can be satisfactorily executed. There is no risk to be incurred during the winter, as the prevailing winds coming from the west drive the miasma towards the sea. The water covering the surface of these swamps diminishes by the action of solar heat, winds and infiltrations, passing from winter to summer. The shores of these pools are often of such a feeble inclination, that they remain in the state of mud and produce miasma. Thus we have annually a very unwholesome surface, according to circumstances. The marshes, the bottom bed of which is wholly situated above the level of high water, can be drained by a main drain, which will prevent them from being covered with water. In default of sufficient inclination, the water would be stagnant in the canal, so that M. Poulain proposes to fill up by artificial means the deeper parts of the swamps or pools. These latter require some management; the main drain should be

furnished with one or several metallic valves fitted on to a sluice opening to sea-ward, upon the pressure of a few centimetres of water. The valves serve perfectly for the flow of rain-water, even for a large surface, if the ground permits, and the sluice only fulfils the duty of hindering the canal from being silted up by sand, &c.

The ideas newly put forth by M. Poulain, consist in utilising, on a large scale, the sea for draining the shore by putting it into communication with swamps and pools, so as to renew the saline water of the marshes, and raise or lower the level so that it shall be always sensibly the same. Those whose level is constantly and entirely below that of the sea in summer, are otherwise treated, and he takes as an example the pool of Biguglia, which is very large and miasmatic; situated very near Bastia, it spreads the deadly emanations to the very town. The swamp contains 1370 hectares, to which must be added 304 hectares, making in all, 1674 hectares (4136 acres, I. R. 32·6 p). Its level varies from 0 to 5 feet above the level of low water, and its greatest depth relative to this level does not exceed 7½ feet. Thus it is plain, that the annually dangerous surface is of vast extent. The pool, 7¾ miles long, is separated from the sea by a dune of sand, very narrow, but of regular width in general, the minimum width being a little over 600 feet. It has been known for centuries as the dune or hillock, and is marked on the most ancient charts.

By canals which communicate with the swamps and the Mediterranean at each tide,* the level of the pool being entirely below the sea level in summer, the sea water introduced in proper quantity into the marshes would renew the water of the pools, and contribute towards their salubrity; the extensive annually dangerous surface, corresponding to a depth of 5 feet below the sea level of low water, without taking into account all that is above, would be replaced by a surface of considerably reduced dimensions, corresponding to a fluctuation of a few inches only, for example, and constantly bathed with healthy water. This system, of which we give a rough sketch, leaving the calculations for the end of the chapter, would not be very expensive. It consists in simply opening across the narrow dune, narrow and shallow channels, the bottom being a little below the lower sea level, and to continue them, to protect the embouchure

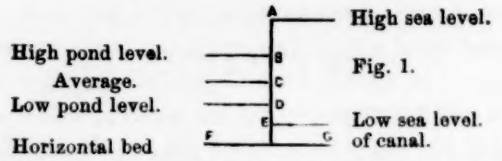
* It is erroneously supposed that the level of the Mediterranean is constant and the sea tideless. It ebbs and flows, and Captain Smyth, who surveyed many of the shores, states that he found a tide, small certainly, but decided, although not governed by the moon. Admiral Fitzroy also remarked a rise and fall. Also the tidal current in the Fars of Messina is well known.

by small jetties, carried downwards to only a few yards below low water, as beyond the depth of two yards the sands are very rarely displaced. The dune should be well planted, in order to prevent the sands from being transported by the wind.

The unhealthy pools (they are not all so) and the marshes may be surrounded by a very thick and continuous belt of olive or other suitable trees, which can act as an additional barrier against the miasma. This is the system proposed by M. Poulain for draining or purifying the marshes on the eastern plain of Corsica, and it can be carried out economically by improved mechanical means, such as portable engines, excavators, &c. It is possible that these works would not exceed eight dollars an acre, which is very little, considering the great benefits resulting to the property situated in the east of Corsica. The expense will be covered by the application of the law of the 16th September, 1807, a special law which obliges the proprietors of the neighboring lands, both plain and valley, each to contribute a portion of the expense, according to the benefit received by them in a sanitary point of view. M. Poulain is of opinion that a pool or lake, situated very near the sea-shore, the level of which is constantly below that of the sea, can be rendered healthy by putting it in communication with the latter, by means of canals, so that the fluctuations of a few inches on either side of the mean level can be the result of the more considerable oscillations of the sea. The dangerous surface becoming thus constant, and of small extent, washed, besides, by renewed water, can be made to lose entirely its putrid qualities. It is therefore necessary to know, at least approximately, the width of the canals which will give fluctuations of $\frac{1}{8}$ths of an inch about, for example.

The solution of this problem is very complex on the one hand, because many of the laws of hydrodynamics are yet to be found; on the other hand, because we reach expressions under the sign $\int$ that we cannot resolve. M. Poulain furnishes us with approximate numerical solutions. He supposes that the pool is put in communication by an horizontal canal. The water of the sea will be poured into the pond, and *vice versa*, that of the pond will flow into the sea, according to the rise and fall of the latter. When the water has attained its maximum height in the pool, it will receive no more, and will be at the point of yielding it.

There will exist *at the same moment* a common level between the sea and the pool, for the highest and lowest levels of the latter.



B D represents a demi-fluctuation of the pool, whether the water pours inwards or outwards, that is to say from the sea to the pool, or from the pool to the sea. The flow of water by the same horizontal canal, will be subject to the same laws, in both directions, unless we take into consideration atmospheric circumstances, which we have no reason to pay attention to here; it will be constant, but alternatively positive and negative, and consequently the horizontal lines B and D will be equidistant from A and E, which represent the high and low levels of the sea (B A = D E), or in other terms are mean levels of the ponds, and the sea will coincide.

Fig. 1 shows that the pond when at its lowest, I, will be in the process of filling when the sea rises from D to A, and falls from A to B, and that it will be on the contrary in the course of emptying, when the sea falls from B to E, and rises from E to B. It is also evident that the mean levels of the pond and the sea, which are the same, are not simultaneous.

[The learned author here plunges into an ocean of calculus, from which he emerges after a time, with the following conclusions rescued from the devouring element.—Ed.]

For a variation twice daily of two centimes of level in the pool, a canal 15 mètres wide is necessary. If we wish to renew the water in the pool in a greater proportion, several similar canals must be opened on chosen points; and then the variation of the level in the pond, instead of being two centimètres, can be increased to four or five, which would be excessive.

Also, if the bottom of the canal be paved with stones, no injurious effects would be produced by the currents. The following table is of interest in this connection.

	Per Sec. M
Wet soils begin to be transported by water moving at the rate of	0·07
Soft clays " " "	0·15
Loose sands " " "	0·30
Gravel " " "	0·60
Pebbles " " "	0·61
Broken flint stone " "	1·22
Agglomerated pebbles soft pudding stones and stratified rocks " "	1·83
Hard rocks " "	3·65

F. Moigno.

OUR NEW YORK LETTER.

NEW YORK, *January*, 1868.

SOME ten or a dozen years ago, a charter of incorporation was granted by the Legislature of this State for the formation of the "American Society of Civil Engineers." Mr. James G. Laurie (who was the first President), is entitled to the credit of its origination, and many of the most noted engineers in the country were enrolled among its members. It was the anxious desire of all to make the Society felt as a power, besides establishing a bond of fellowship and an *esprit du corps* in the profession.

Lack of funds, however, prevented the Society from establishing permanent headquarters, as was necessary, and meetings were held in the office of Alfred W. Craven, Esq., the present head of the Croton Aqueduct Department. Interest in its proceedings gradually failed from one cause and another, until finally the Society existed merely in name, and in the memory of its members. During its brief existence certain moneys accumulated, and had been invested for its benefit. Last fall, some of the old members met together, and determined to revive the old Society on a new basis, and invited the coöperation of their professional friends. The movement met with hearty approval, and thus encouraged, the accumulated funds were expended in handsomely fitting up a couple of pleasant rooms for a down town exchange, and a reorganization was immediately put in force. The first meeting was held last December, and Mr. James P. Kirkwood was elected President, with Col. Julius W. Adams as Vice, while Mr. James O. Morse, the original Secretary of the old organization, was still kept in office.

At this meeting the President delivered a most excellent and practical address, going over the ground of the past difficulties of the Society, and pointing out wherein he conceived the element of success lay. He dwelt especially upon the importance of professional papers and communications, as being essential to keeping up an interest and life among its members. Such papers should be printed and distributed among all non-resident members, who should feel obliged to send on their experiences and observations, be they small or great, for the edification of their resident brethren. It was an address replete with sound and honest advice, and was heartily responded to by the members present. The Committee on papers

and printing have printed this address in connection with a short circular, urging all members to take hand and make the Society in reality what it aims to be—the exponent of the engineering profession in America—and to hold the same rank and position as the English Institution of Civil Engineers, or the similar organization of France. Judging from the spirit that now actuates the members, little fear, I think, may be had of the future; and we hope to do much towards educating the public in the idea that engineering is not a trade, but a learned profession, practised by gentlemen. At the January meeting, a full attendance showed the interest felt; and a valuable paper was read by Mr. Craven on the breakage of some of the enormous ten feet mains of the Croton Aqueduct. A communication was read by the Secretary, Mr. Morse, from Mr. McAlpine, upon the subject of corrosion of cast iron immersed in sea water. After citing numerous experiences of his own and others, he is of the opinion that cast iron piles are not subject to any corrosion whatever, if the ore from which the iron is made is properly selected. *Soft* cast-iron will rot and become spongy, turning into a graphitic substance; but *hard* grey iron castings have never been known to fail by corrosion. Most of the members feel now that the Society has fairly been launched on a successful career, and may God speed its mission. Many of the oldest and most experienced engineers in different parts of the country have signified their willingness to take hold and put their shoulders to the wheel, and to give it such assistance as may lay in their power.

The meetings are held, at present, at one o'clock, P. M., as the location of the rooms in William street is in the strictly business portions of the city, and were so chosen, as well as the hour, in order that no excuse could be had for non-attendance of the members. If for no other reason it is agreeable to think that our own migratory profession has a head-quarters in this the commercial centre of the country, where they can meet their brethren, fight their battles over, and extend their acquaintance. As long as New York is the great centre of capital, so long will engineers be drawn hither in the development of their schemes and projects, more than to any other point. How important it is for them that the American Institute of Engineers should be a success. The time is coming, too, when New York will have her Great George street, where engineer and contractor will be sought for, when pro-

fessional employment will come seeking them, and not they the employment. The day is not far distant when capitalists will call in the aid of the professional engineer instead of the "practical" man who has heretofore been depended upon, and when the scientific engineer will cease to be ignored, as merely a "paper" and "book" engineer, which the public find very hard to harmonize with their notions of a "practical" man.

The fearful rigor of the winter has put a stop to public improvements, although many are on the tapis. The elevated railroad is not as yet running, being unexpectedly delayed. From present appearances, it will be a month yet before things are in such a shape as to test the practicability of Mr. Harvey's scheme. A perfect inundation of bills for the "relief" of New York are pressed upon the Legislature now in session. Everything tends to the underground this year, and, if carried out, would honey-comb this unfortunate city from one end to the other, and expend, in so doing, the amounts of several national debts. One of the schemes embodies what the *Tribune* facetiously calls a pop-gun under the East River from this city to Brooklyn, through which passengers, &c., may be blown back and forth by compressed air, in no time whatever. I have not heard the time estimated that it will take to blow a passenger from the Battery to Washington Heights, but I think that it is somewhere in the neighborhood of three seconds —perhaps not so much. The "Nolan" project to excavate Broadway from building to building, and have an arcade with stores, besides innumerable freight and passenger roads run with gas-consuming "dummies," is strongly pressed this winter at Albany. The little difficulties of sewers, gas pipes, water mains, &c., to be met by pipes, supported on columns, and the street level is made by paving on huge iron girders, supported on plates and columns. The iron men think this a grand scheme, and certainly ought to be instituted. The people who own property think that *perhaps* their stores might tumble down when they were undermined; but, pshaw! that's nothing these days, when we reflect upon the company that proposes to tunnel the Atlantic, disgusted with the long ten days that it takes to cross that ocean. The East River Bridge has progressed no farther than the borings, and perhaps the Union Ferry Company don't purpose that it shall. The Brooklyn Councils will be asked, shortly, to subscribe three millions to the stock of the Company, inasmuch as they have not

succeeded in having it taken by outsiders. Col. Adams has published a severe criticism of Mr. Roebling's plan, which is caustic, if not altogether just.

The Hudson Highland Suspension Bridge Company is applying for a charter to build a bridge over the Hudson from Verplancks to Buttermilk Falls; the capital (two and and a half millions), with power to increase. It is one of the schemes of struggling Bostonians to get a little direct western trade, especially coal, without breaking bulk. The railroad companies are expected to subscribe largely, especially poor bleeding "Erie," who don't see it, and cannot understand why she should cut off her New York terminus to please Boston. Turner's, in Orange county, would be the point at which trains would leave the Erie road. As the roads that would use it are not yet built, this bridge may be regarded as also in the future. It takes New York to get up big schemes of all kinds, characters and descriptions.

The N. Y. & N. H. R. R. will put on, this week, compartment cars for their Boston through travel, which will be a great comfort for our aristocratic Americans who do not like to travel in the usual democratic manner, with everybody and anybody.

I noticed, at Van Nostrand's, the other day, a new and revised edition of Barlow's Strength of Materials, brought up to date by Mr. Humber. It is a work full of observed facts, and one that every engineer ought to have by his side in designing constructions. In an appendix the effect of "gradients," as also the effect of "moving loads on rails," is most admirably and judiciously discussed to a greater extent, and with more practical results, than in any other book I have seen.

Van Nostrand, who is sole American agent for Colburn's "Engineering," tells me, for a scientific periodical, that it has a most extraordinary circulation, and is constantly increasing. I know of no professional journal so worthy of success, and its weekly visit one learns to look forward to. It is a marvel of cheapness, too, and is conducted with an energy and zeal that insures a success. Its superb paper and print, with its unsurpassed engravings illustrating every new thing under the sun, are features that make this journal a real pleasure to read.

A. P. B.

Civil and Mechanical Engineering.

RUTHVEN'S HYDRAULIC PROPELLER.

By Isaac Newton, C.E.

No project for the improvement of steam navigation, so far as regards the propelling instrument, since the screw propeller was made a practical reality by the distinguished engineer, Ericcson, some thirty years ago, has attracted more attention than Mr. Ruthven's water-jet, as applied in the British naval vessel *Waterwitch*, and also in one or two smaller vessels.

For upwards of a year the English press, both secular and scientific, has devoted a large portion of its columns to accounts and discussions of the relative advantages and the efficiency of this contrivance. These discussions have given to the Hydraulic Propeller an importance in the eyes of nearly all who have read them, with the exception, perhaps, of a few professionals, which an analysis of its construction and an examination of its performance will show is far beyond that to which it is entitled on the grounds of its merits. The apparent simplicity of this method of propulsion—the propelling instrument being concealed, as will presently be shown, in a box within the vessel—has doubtless caused by far the greater number of those who have witnessed the trials with the *Waterwitch*, to entertain erroneous views with respect to the efficiency and capabilities of this apparatus. Admiral Farragut, in a report to the Navy Department, on the occasion of a short trip which he made in this vessel, on the invitation of the Admiralty, says:—"So soon as we got on board we proceeded out of the harbor, and, to my amazement, she went ahead at a speed of seven or eight miles per hour, against a fresh breeze and quite a 'sea.'" If the gallant Admiral had reflected on the disproportionate expenditure of steam-power which was necessary to achieve that speed, he would have seen that the same power applied to an ordinary propeller would have given a very much higher velocity to the vessel; and could he have taken a peep at the propelling instrument, which is concealed in a huge cast iron box, he would have been amazed to find, that while the *Waterwitch* is but about one-fifth of the size of his flag-ship, the *Franklin*, her hydraulic propeller is heavier and more bulky than the simple screw of the

heavy frigate. In order to make the principles and peculiarities of the hydraulic propeller intelligible to those readers who have not given attention to the subject, as well as to render the description, which will presently be given, of the machinery of the *Waterwitch* more easily comprehensible, we will give a brief elementary explanation of its mode of action. Propulsive force is applied to the vessel simply by the discharge of a column of water from two nozzles—one placed on each side of the vessel above or near the water-line—and pointed directly opposite to the direction in which it is desired to drive the ship. The force which propels the vessel ahead is produced in precisely the same way as that which causes the arms of that familiar philosophical toy known as Barker's mill, to revolve; that is, by the reacting pressure which is produced by a fluid flowing out of an orifice; this pressure will, of course, vary as the square of the velocity of the flow. The familiar example of a rocket will make this still more clear. A rocket, as is well known, is forced through the air by the continuous pressure produced by a stream of gas rushing out of the body of the rocket in a direction directly opposite to that in which it is driven. Substitute a stream of water for the stream of gas, and let it flow with the velocity necessary to give the same pressure that is created by the gas, and the result, as regards the propulsion of the rocket, will be the same. And, on the other hand, if it were possible to cause a stream of gas to issue from the stern of the ship, sufficient to produce the same pressure in relation to the resistance, as is the case with the rocket, the vessel would be propelled ahead with equal velocity. Now that the principle of the hydraulic propeller is understood, we will proceed to give a description of its application to the *Waterwitch*, as brief as is consistent with clearness, as well as the dimensions of that vessel, and then make a comparison between this instrument and the ordinary screw propeller, in order that their relative merits and comparative efficiency may be plainly set forth. This we are able to do accurately, as working drawings of this machinery are lying before us.

The *Waterwitch* is 162 feet in length between perpendiculars, by 32 feet breadth of beam and 13 feet 9 inches depth of hold; her average draft of water is about 11 feet. She is rather flat-bottomed, and is built double-ended, with a rudder at each end. We now come to the propelling machinery. Nearly midway, in a fore and aft direction, and in a precisely central position transversely, on the bottom of the vessel, a long shallow box of iron is riveted; this box

extends seven feet on each side of the keel, and for a distance of about twenty-two feet in the direction of the length of the vessel. The lower side of this box (or rather the bottom of vessel which forms its bottom), is pierced with a great number of small rectangular orifices, which give admission to the water on the outside of the vessel; there is a partition in the box which divides the part which communicates with the sea from the other portion which has no such communication: this partition is fitted with sluice valves, so that the water may be shut off or regulated from one portion of this box. On top of the latter portion of this box the hydraulic propeller or centrifugal pump is placed with its axis vertical. This pump, or rather wheel, is circular; it is 14 feet 6 inches in diameter, and weighs no less than 8 tons. It is constructed of two boiler-plate disks, curved somewhat like a saucer, and placed about 2 feet 3 inches apart; these disks are secured to a cast iron centre, which is in turn attached to the shaft of the engines, by means of which it is revolved. Between these disks, and riveted to them, are placed twelve arms or blades, thus dividing the space between the disks into twelve spaces one end of which communicates with the water-box already described, by means of a circular hole 6 feet in diameter, cut in the lower disk, and the other end terminates at the circumference of this wheel, or, more properly, centrifugal pump. The blades or arms are curved in a peculiar manner, which it is not necessary to describe for a clear understanding of the subject. Surrounding and enclosing this centrifugal pump, and bolted to the water-box already mentioned, is a cast iron circular case, in which it revolves; this case is 19 feet in diameter, and it is made with great care, being accurately *turned* and polished throughout its interior surface; the object being to reduce the friction of the water forced against it by the pump to the lowest possible point. Leading from this case, in opposite directions, are two rectangular-shaped discharge-pipes, made of copper, and curved so as to reduce the friction of the water. These discharge-pipes lead to the nozzle-pipes, which are attached to the exterior of the ship's side, at or about the water-line—the discharge-pipes within the vessel are 2 feet 1 inch by 2 feet 3 inches, and the propulsion nozzles on ship's side are 24 inches by 18 inches; and they are continued 8 feet in a fore and aft direction each side of the centre. These nozzles are two in number on each side of the vessel, one pointing forward and the other aft; by means of valves in the discharge-pipes, which can be operated from the deck, the stream of water can be pro-

jected aft or forward, thus changing the direction or turning the vessel at will. On the top of the circular pump case, and rising far above the water-line, are placed the steam-engines for driving the centrifugal pump. They are three in number, and are connected directly to the shaft of the pump on one crank-pin, at an angle of 120 degrees with each other. Their cylinders are 38½ inches in diameter, by 3 feet 6 inches stroke of piston.

The whole of the machinery is elegantly proportioned, and the workmanship is as fine as it is possible to make it. The centrifugal pump or hydraulic propeller "and its casing and copper propulsion pipes are all marvels of workmanship." The machinery, exclusive of the boilers—*i. e.* the propeller, its engines and pipes—occupy 29 feet of the length of the vessel, by the full interior width, and in height 13 feet from the bottom of the vessel; in a word, 10,556 cubic feet is required for the propelling machinery. It will now be proper to devote a few words in explanation of the mode of action of this contrivance. The sluice valves which separate that portion of the box (attached to the bottom of the vessel) which is open to the sea from that portion which opens into the six feet-diameter circular hole in lower disk of the pump being opened, the water enters and fills the spaces between the radial arms or blades which have already been described. The centrifugal pump is now made to revolve by means of the steam-engines attached to its axis, and the water contained within the spaces is driven out by centrifugal force into the cast iron case, and passes from it, by means of the pipes, to the propulsion nozzles which are attached to each side of the vessel. The velocity and quantity of the water thus projected, in a direction contrary to the motion of the vessel, is, of course, governed by the perfection of the apparatus; and in this respect the performance of this particular design seems to reach the maximum possible, being, as it is, the result of the experience of some thirty or forty years of experiment and mathematical investigation; in a word, no greater increase in the ratio, between the useful effect and power applied to a centrifugal pump, than is in this case achieved, seems to be possible.

Now that the construction, arrangement, and mode of action of the centrifugal pump, employed as a propelling instrument for steam vessels, have been explained, it would seem that a comparison between it and the screw propeller, is properly the next step in this investigation. And this, because in bringing out the points of difference and the advantages claimed for the one instrument over the

other, the probability of the introduction of the hydraulic propeller will be readily seen.

Let us, in the first place, compare these two propellers, under the assumption that they both possess equal propelling efficiency—that is, that each of them transmits the same proportion of the power used in driving them, to the propulsion of the vessel. In the next place, we will glance at their relative efficiency as instruments to transmit the power of the engine to force the vessel through the water. With respect to the first comparison: The screw propeller, it is almost unnecessary to state, consists of a central hub, with (usually) four helical blades attached to it. This propeller is fastened to a shaft which—if a single propeller is used—projects through the stern-post beneath the water-line. Such an instrument as this, to properly transmit the power developed by the engines which drive the centrifugal pump of the *Waterwitch* (viz: from 7 to 800 horse-power) would require to be about twelve feet in diameter, and would weigh only about four tons, and engines to drive this propeller, of a sufficient size to work up to 800 horse-power at a moderate speed and a moderate pressure of steam, would not occupy more than 1350 cubic feet in the vessel—that is, 150 square feet on the bottom of the ship by 9 feet in height. Now, contrast this with the enormous space required within the vessel by a hydraulic propeller and its engines (the *Waterwitch*) necessary for the utilization of the same power—that is, 29 feet in length by 28 feet in width by 13 feet in height—10,556 cubic feet, or nearly eight times as much as would be necessary with a screw.

And when we contrast the enormous space—29 feet in length by 28 feet in width by 13 feet in height—10,556 cubic feet—required within the vessel by the hydraulic propeller and its engines for the development and application of the same power as that required by the ordinary direct-acting screw engine attached to a propeller placed *without* the vessel, and consequently occupying no room within, it would seem to be a formidable point against the hydraulic method. For instance: If, as is the case with the beautifully designed machinery of the *Waterwitch*, upward of 10,000 feet cubic are required to apply and utilize but 771 horse-power, it would require upward of 83,000 cubic feet (that is 60 feet of the middle and best part of the vessel by 43 in width, and by the whole depth from the floor to the main deck) to apply and utilize the 6400 horse-power given by the engines of the English ship *Bellerophon*, which

only occupy 29 feet in length by 30 in width by 13 in height, from the floor, or 11,310 cubic feet, which is but a trifle more than that occupied by the 771 horse-power contrivance in the *Waterwitch*. It seems, therefore, almost unnecessary to remark, that on this ground alone, it is quite impossible to apply the hydraulic propeller to a first-class ship of fair speed. And we may here remark, recapitulating somewhat, that, from the foregoing, it appears to be evident, that the hydraulic motor cannot be economically employed in freighting and passenger vessels, even of medium steam-power, on the grounds of the great weight and space required for its use, and its consequent cost, as well, also, as its inferiority as a propelling instrument, as compared with the propellers now in use.

Again, let us look at the relative weights of engine and propeller required for the two methods of propulsion, bearing in mind, as we have done before, that we have assumed both systems to be of equal efficiency as propellers, and the problem is to apply and transmit equal power—in this case 771 horse. We have stated that a screw, to properly use 771 horse-power, would require to be about 12 feet in diameter, and would weigh about four tons; and a direct-acting screw engine, to develop this power at moderate speed, and with a moderate pressure of steam, would weigh, as ample experience proves, some 40 tons; hence the engines and propelling apparatus, collectively, necessary for the screw system, would weigh not over, say, 50 tons.

As to the engines which drive the centrifugal pump of the *Waterwitch*, it is not safe to place them at less than 45 tons; the centrifugal pump itself weighs 8 tons, and the 19 feet diameter casing of cast iron which surrounds it, together with the water-boxes, sluice-valves, propelling nozzles, &c., must weigh at least 50 tons more, and to this must be added the weight of the water required to fill the enormous casing, the propulsion pipes, water-boxes, &c. (and they must be filled when it is in operation), and this is certainly 40 tons more. Here, then, we have an aggregate of no less than 143 tons required for the hydraulic propeller, against 50 tons required for the screw propeller; this would seem to be another point against the former.

Now that attention has been directed to the above features, it is proper to state those points which the advocates of the hydraulic propeller claim mark its superiority over the screw. A number of these claims for superiority are for the use of the hydraulic motor in vessels of war, but they will be seen so readily that they need not be specially pointed out.

1. That the propeller being wholly within the vessel, the risks from shot or fouling are avoided. As the screw propeller is usually wholly beneath the water-line, it is almost impossible to injure it by shot, and if one of the blades, which sometimes project a short distance out of water, should be hit, it would only injure it by breaking a piece off its end, not a very serious matter. There is no case on record of a screw propeller being injured by shot. Instances of screw propellers fouling are now very rare, and that without any appliances to prevent it. No vessels have been exposed to more danger of fouling their screws than were the monitors in Charleston Harbor and elsewhere; yet in no case were their screws fouled, notwithstanding the endeavors made by the enemy to disable them in this way; this is doubtless due to the application of one of those small but important inventions which necessity sometimes brings out; this extremely simple anti-fouling contrivance of the monitor can be applied to any screw vessel at trifling cost, where such precaution is deemed necessary, which is not the case with vessels of peace. On the other hand, the use of the hydraulic propeller renders the propelling power much more liable to be disabled by shot than is the case with the screw. And this for the reason that at or above the water-line (*Waterwitch*) there is on each side a propelling nozzle 16 feet long, with a discharge orifice in each end 24 inches by 18 inches. Although these big boxes sticking out on each side of the ship may be covered by heavy armor-plates, artillerists know that a shot from a modern gun would break them in and utterly destroy the propelling power of the vessel; if the attempt is made to make these excressences invulnerable by the employment of thick backing, heavy ribs and very thick armor, they will at once assume such cumbrous proportions as to put this plan out of the question.

2. The next great claim is the superior manœuvring power which the hydraulic propeller gives to the vessel. This manœuvring or turning power is accomplished by directing the discharge from one nozzle astern, and the other ahead. On this point a high authority says:—"The hydraulic vessel (the *Waterwitch*), discharging her water ahead from one nozzle, and astern from the other, took about twice as long to turn as the double screw vessel (like our monitors of the *Monadnock* class), viz: about $6\frac{1}{2}$ minutes as compared with $3\frac{1}{4}$."

But with either the double screw or the hydraulic, experiments prove that the manœuvring power is much less than is generally supposed, and that because the turning power acts at so short a distance from the centre of gravity of the vessel.

3. That with the hydraulic propeller the vessel can be reversed without reversing the engines, and that this operation can be performed by an officer on the deck. The reversing is effected by moving two enormous valves in the propulsion pipes; if these valves get out of order, not only is the power of reversing destroyed, but also the propeller itself—a disadvantage which engineers will not admit is compensated for by the suppression of the extremely simple reversing gear usually attached to the engines. If it is desired that the officer of the deck should operate the engines from the deck, it can be very easily accomplished by leading-rods from the engine to the deck. There has been a double-screw tug-boat running in New York Harbor for many years, where the throttle-value and reversing handles are in the pilot-house, and the officer of the deck steers, stops, starts, backs, or turns his boat without moving from a high stool. Can the hydraulic propeller do more?

4. That the hydraulic will be less affected by the motion of the vessel in a sea-way than the screw. Quite the contrary; rolling, while it does not affect the action of the screw materially, would operate seriously against the action of the propelling power of the water issuing from nozzles alternately depressed many feet into the sea, and raised equally high out of water. And as for pitching, the screw engine is now as accurately controlled by the governor as an engine in a cotton mill. There are other points claimed, but they are of no consequence, besides want of space warns us that we must bring this account of the water motor to a close.

And we will therefore speak of the last comparison we now intend to institute between the hydraulic propeller and the screw propeller, and that is their relative efficiency as propelling instruments. By efficiency is meant the ratio between the power applied by the engine to the propeller and the power utilized in urging the vessel through the water; the difference between the power developed and power so applied is, of course, wasted in doing work which accomplishes nothing towards driving the vessel.

In order to make this comparison perfectly clear, it is only necessary in the first place to quote the results from the official trials of the *Waterwitch*, and compare the power which is required to propel her at a certain speed with that which is necessary to propel freighting propellers of similar model in this country at the same speed. To begin with, we find from the official dimensions given of the *Waterwitch*, that her model is better than that of our freight pro-

pellers on the North River and Long Island Sound. Those familiar with the subject will understand this when we state that between 35 to 40 per cent. in her model is cut away from the solid, represented by her length, breadth and mean draft; which shows pretty conclusively that her model is even better than that of our propellers with which we wish to compare her. Now, referring to the official accounts of the trials of the *Waterwitch*, the following is the result:—Immersed mid-section, 347 square feet; horse-power, 777; speed, 9·2 knots—that is, by the usual calculation, 2·8 horse-power are required for each square foot of immersed mid-section to give a speed of 10 knots; and very extensive experience with our bluff freighting propellers shows that but 1·8 horse-power per square foot of immersed section is neeessary for the speed of 10 knots. Hence, it is evident that the hydraulic propeller in the *Waterwitch* is, as a propelling instrument, 36 per cent. less efficient than the ordinary screw propeller; or, in other words, it wastes 36 p. c. more power than that method of propulsion. Why there should be more loss with the hydraulic than with the screw, it is quite easy to show mathematically; but we may rest contented here with having demonstrated the fact, without giving the reasons of their sources of loss. As respects the merits of the two systems, we may say, in recapitulation, that it has been proved that, even provided the two systems possessed equal propelling efficiency, that the screw possesses very marked advantages over its rival; but as it has also been established that the screw far exceeds the hydraulic in propelling efficiency, the conclusion that the hydraulic method cannot compete with the screw propeller, it would seem cannot be gainsaid. One more comparison, and we will tire the patience of the reader no longer. In the year 1837, the British Admiralty were towed ten miles an hour on the Thames by a screw propeller. They shook their heads at the scheme, and pitied the inventor for his sanguine credulity; the same propeller, with almost identically the same proportions, is the motor of all the navies of the world, and has now almost driven the paddle wheel from the ocean. In 1867 the British Admiralty make sundry excursions with the hydraulic propeller, and are infatuated with its merits, and this contagion of enthusiasm seizes the English press, and an ancient motor, promulgated as long ago as 1661, receives as much attention as though a new era had been commenced in naval warfare by its resurrection.

THE SUPPORTING POWER OF PILES, BOTH OF WOOD AND IRON, AND THE USE OF THE LATTER, EITHER AS PILES OR COLUMNS OF SUPPORT FOR FOUNDATIONS.

A PAPER READ AT THE FRANKLIN INSTITUTE, JANUARY 15, 1868, BY HON. W. J. McALPINE, LATE STATE ENGINEER OF NEW YORK, ENGINEER IN CHIEF OF THE U. S. DRY-DOCK AT BROOKLYN, MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS OF LONDON, MEMBER OF THE FR. INST., &c.

(Continued from page 110.)

If the sand is free from logs and stone, then small piles may be used, say of one foot diameter, with expanded iron bases.

Assuming that the weight of the pier, superstructure and load, is fifteen hundred tons, and that such piles are driven to a depth of sixty feet below low water, with a scour of thirty feet, the external frictional surface of the remainder of the pile and the area of the base, will afford a sustaining power which will require about thirty piles to carry the load with safety, and with the grillage on top, ready to commence the masonry of the pier at low water, will cost about thirty thousand dollars ($30,000.)

If logs or stone are encountered, the iron columns must be enlarged sufficiently to allow the workmen to descend them, and remove or cut away the obstruction.

The least diameter which will permit of this descent is thirty inches, and in this case there must also be provided a working chamber at the bottom, of probably five feet diameter.

This chamber can be made by a conical instead of cylindrical pipe at the bottom, which must be made thicker than the other parts of the column, as a greater part of the load will be carried by it, with a strain partly across the shell. It may, at first, be supposed that the column with this shaped bottom, will be more difficult to drive, but it will be seen that with any process of interior excavation, the column in this shape will descend with even more facility than if cylindrical.

In addition to the increased bottom support which this expanded base of iron will give, the concrete filling may be extended below the bottom of the column from four to six feet, and also beyond its external lines from two to three feet, thus giving a further expansion of the base, equal to eight feet or more in diameter.

Nine such columns will bear the assumed load with safety, and with the grillage, ready for the masonry, will also cost about thirty thousand dollars ($30,000.)

A pier, wholly of iron, may be made, and would consist of two columns of eight feet diameter and one hundred feet long.

They would require to be cross braced with iron, and a starling made either of iron or wood. I prefer the latter, and would propose to make it by sinking two small columns or piles, of fifty feet length, at the upper extremity of the pier, to sustain a level floor; the lower end of which would be supported on flanges on the main column.

Upon this floor an ice-breaker, in the ordinary form, of wood, well packed in with stone, would be built.

If desired, this timber work could be carried around the columns, and form a protection or guard to the braces.

Timber, under such circumstances, would last ten years, and would not cost $1000 in its renewal.

I have stated my preference in favor of a wooden starling, and this is because it has considerable elasticity, which will take up some of the momentum of the blows of heavy bodies striking the pier, and will save the iron from shocks.

Such a pier, with its braces, starling and capping complete for the superstructure, would cost about forty thousand dollars ($40,000.)

The comparative cost of a stone pier resting on wooden piles, under the same circumstances, would be, approximately, as follows.

Assuming that the mean depth of the water at all of the piers was ten feet below low water, to found the pier at twenty feet below would require ten feet depth of dredging, and to prevent the sand from flowing in would require a curb of ten feet height.

To obtain a penetration of thirty feet with the piles, and to permit them to be driven from above the ordinary stages of the water, would require timbers about sixty feet length. When these were driven and cut off at the proper level, the masonry could be built in a caisson and lowered upon the piles.

Under the assumption that the scour of river will reach to a depth of thirty feet, there will be but twenty feet length of these piles to sustain the load. The load will also be increased to two thousand tons by the extra masonry between the foundation and low water, and will require more than two hundred piles to sustain it.

The cost of such a pier, brought up to the level of low water, would be thirty-six thousand dollars ($36,000), and forty feet higher, viz: to the bridge seat, would be forty-five thousand dollars, ($45,000).

The case which has been assumed, is one of those which shows

most unfavorably against the use of wooden piles; but is by no means a rare one on the western rivers. It, however, serves to show that, under difficult circumstances, the use of iron piles becomes actually cheaper than wooden ones.

There are many cases, however, when the latter will be the least expensive, and also when the more important question of the safety of the piers and structure is involved, and my chief object is to call your attention to this feature.

From what has been said, it will be observed that the iron piles and columns derive the largest portion of their support far below any possible action of the river currents, and therefore, that they may be relied upon for safely carrying the structure under the most unfavorable circumstances.*

If an ice or drift gorge should scour out the sand about the piers to a depth of forty or even fifty feet, the pier and structure would not be endangered.

It is true that these columns, standing like stilts, forty or fifty feet high, would be objectionable if left so for a considerable time; but no immediate injury would ensue, and when the space around them was filled up with stone, as it would be at the earliest convenient time, the piers would forever after be safe against any future scour.

The first use of this system was a process patented in England, by Dr. Potts, to found a lighthouse on Goodwin Sands.

It consisted in exhausting the air from the hollow iron pile, and then the pressure of the atmosphere, the weight of the pile, and sometimes that of an added load, caused it to penetrate into the sand.

The bridges at Rochester and Peterboro', and some others in England, as well as those in this country, were all commenced upon that plan; but, while it answered very well for small piles in a sandy bottom, it was found inefficient with large piles, and of no value when they encountered, in their descent, logs, stone, or even a compact material.

*In arranging the plans of the foundations with iron piles, for the purpose of making the above comparisons of cost, it so happened that a greater number of columns were drawn in the plan than was necessary to carry the load, so that the estimates cover the cost of a much larger sustaining power than was provided for in the case of the wooden piles. If any exception should be taken to the estimated cost of the latter, it may be answered that corresponding reductions may be made in the former. The object of the comparison, however, is merely to demonstrate that foundations with iron piles may be used at a moderate cost.

Messrs. Cubitt and Hughes, the Engineers of the Rochester Bridge, in 1849, and Messrs. Gwynne and Fleming, the Engineers of the Pedee Bridge, a year later, changed the process from the vacuum to a plenum; that is, they expelled the water out of the column by forcing in it air, condensed to the same pressure as that of the surrounding water, and the workmen excavated the material from within the column. The entrance of the men and the outlet of the material excavated, was made through a chamber on top, provided with valves in the top and bottom.

Various other improvements were made in the process, which will be spoken of in another place in this paper.

A synopsis of the European practice of this system, embraces as follows:—

1. Columns of cast iron, from seven inches to twenty feet in diameter, the metal of the small ones being half an inch thick, and of the large ones, one and a half inches, driven by the vacuum and plenum process, by the hydrostatic process, or by manual and machine excavation. These columns have been driven from seven to seventy-five feet into the sand below low water. They have generally been filled with concrete, on which the superstructure is carried; but in some cases it rests upon the iron shell. These columns are generally carried up to the superstructure, forming piers entirely of iron.

2. Columns or caissons of wrought iron, of cylindrical and other curved forms, and of rectangular ones, the metal from one-eighth of an inch to half an inch thick, driven by the pneumatic process, or sunk by the aid of heavy weights to moderate depths into the earth, the excavation being effected by manual and machine work. In these cases the caisson is filled with solid masonry, forming a base of the usual form for stone piers. In India, columns of brick are used, shod with iron or wood.

For the St. Louis Bridge a plan was submitted last summer, of a timber caisson-bell sufficiently large to build a pier 100 feet long and thirty feet wide, to be placed in a dredged pit 30 feet below low water, with its top extending to 20 feet above water. The lower portion was an inverted caisson, composed of 12 compartments, each of which were 16 feet square and 12 feet high. The upper portion was a direct caisson of the usual form, the sides of which were arranged to be removed after the masonry was completed: the lower caisson and its roof was to be left in permanently.

I arranged plans for a similar inverted caisson, in wrought iron and in compartments, for the straight piers of the Harlem Bridge. The description of this caisson is given merely to indicate one direction to the modification of the principle.

Cylindrical columns of plank, or rectangular ones of timber, and plank shod with iron, could occasionally be used. In that case, however, the filling must be of a material which will support the structure in the event of the decay or removal of the wooden shell.

Various processes for driving these columns have been used. The vacuum and plenum pneumatic processes have already been spoken of, and the latter will now be more particularly described as I employed it at Harlem.

The pile consists of a number of hollow cast iron cylinders, A A,* six feet in diameter, 1¼ inches in thickness and nine feet in length, provided with flanges on the inside, by which they are bolted together, one on the top of the other, until the desired length is obtained. The lower cylinder is chamfered at the lower edge down to about a quarter inch thickness. From a platform, on temporary wooden piles or large scow boats, a derrick is placed, which suspends the column and lands it with the sharp end on the bottom of the river in the place where it is to be driven. Another cylinder, B, called the air-lock, is placed on top of the column, usually made of boiler iron sides, of the same diameter as the columns, with a top and bottom plate of cast iron, in which are man-holes, C C, that can be closed at pleasure by plates, D D, with hinges opening on the lower sides, and lined with rubber at the joints. In the top and in the diaphragm or lower plate, are cocks, E E, usually two inches in diameter. Leading from the outside of the air-lock near its bottom, are two curved tubes, F, four inches in diameter, which also pass through the diaphragm and are closed by cocks. The air-lock is bolted to the top of the column. Small air-pumps, usually worked by a small steam-engine, are connected with one of the curved pipes in the air-lock, by means of a flexible four-inch tube. The lower man-hole plate is then closed, and air is forced into the column.

With the first stroke of the air-pumps the operation of compressing the air commences, and as this pressure increases, it forces the water out through the open bottom. This continues until the pressure of air equals that due to the head of water outside the column, and the water has all been forced outside. The workmen then enter the air-lock, and, closing the upper man-hole, a cock is

* See plate facing page 98.

opened in the lower diaphragm, and the compressed air from below is admitted. When the pressure has become equalized, the lower man-hole plate falls, and the workmen can pass down on ladders to the bed of the river to excavate the material, which is raised in canvass bags to the air-lock, by means of a drum, G, the shaft, H, of which passes through stuffing boxes to the outside, where it is worked by hand, on signal. When the column has been entirely cleared down to the bottom, care is taken to see that no obstructions, such as boulders, logs, etc., remain under the rim of the column, and the workmen ascend into the air-lock, and, closing the lower valve, the compressed air in the air lock is allowed to escape through a cock in the upper plate. When the air in the air-lock has become equalized with the atmosphere, the upper valve falls, the men pass out and the bags of material are removed. Men are then stationed at the guy ropes and the four-inch cock in the curved pipe is opened, and the compressed air in the column allowed to escape quickly.

The upward pressure of the air in the column, on a surface six feet in diameter, neutralizes the weight to an extent which is governed by the depth of the bottom of the column below the surface of water. By allowing the air to escape quickly, in the manner mentioned, this weight is suddenly restored, with an effect similar to a blow, while, at the same time, the rapid inrush of water at the bottom, causes a complete scouring of the material at and under the sharp rim of the column, and the resistance to driving the column is simultaneously removed.

The friction of the outside of the column against the material through which it penetrates, is greatly diminished by the current of water passing along its surface from the river, on its way downward to the inside. If no rocks, trees, or similar obstructions are encountered, the column will continue to settle quite rapidly during the time the air is escaping, and afterwards, until the material has stopped scouring under the edges, and has compacted itself under the pressure of water sufficiently hard to sustain its weight. The amount of settling in one operation will frequently amount to ten or twelve feet, or even more.

When boulders or logs are met with, the column stops, and it is then recharged with air. The workmen descend and remove the obstruction, and the process already described, is repeated. In this manner columns of the largest dimensions may be sunk to depths of a hundred feet, or perhaps still deeper.

The question has been raised, whether life can be supported at such great depths, and many of the English engineers speak of the ill effect upon the health of their workmen; but this is contrary to my own experience and that of my brother, C. C. McAlpine, who entered the columns daily and remained there for several hours at a time, while conducting some of the more important and delicate operations required. The greatest depth at which we have been under water was over fifty feet. The pressure due to this depth was about 22 pounds to the square inch over the atmospheric pressure; or, with the latter added, 37 pounds; but this again was frequently increased by the extra pressure required to drive out the water through the compacted material around the outside of the column, so that the pressure was often increased by as much as an additional atmosphere, or about 52 pounds per square inch in all, equal to a depth of about eighty-five feet below the surface of the water.

After entering the air-lock it was closed against the atmosphere, and the pressure equalized with that in the column, in the manner that has been already described; and this operation, and the other one of equalizing with the atmosphere when passing out of the column, were the only times when difficulty on the part of the workmen was experienced. Men of certain kinds of constitution sometimes suffered greatly; the blood starting from the nose, ears and mouth, and the pain of changing pressure being almost insupportable upon the eye-balls and drum of the ear. These men were usually of a very nervous temperament, and excitement would induce them to keep their nerves under great strain, which added to their difficulties. No trouble was experienced in procuring men, however, who could bear the pressure perfectly well without injury. A little practice and familiarity soon accustomed them to the circumstances. The muscular action of swallowing would always relieve the ear drum, temporarily, from pain and pressure; but, after a little practice, even this was found to be seldom necessary. With new men the pressure would be let on gradually; but those more accustomed to it did not hesitate to equalize as fast as their means of doing so allowed, or in a space of less than a minute.*

The pressure once fully on, it would be difficult, from any bodily sensations, to determine a difference of pressure amounting to at

* This effect is the same as that produced in a diving-bell, but is much less intense.

least one atmosphere. The effect, while under pressure, is to cause a feeling of exhileration, so sensibly felt by the workmen that a lazy man becomes industrious, and there is seldom occasion to urge any of them in their work. The ventilation is of course, excellent, and the operation of breathing becomes so easy, that the inhalations are slower and shorter than in the usual atmosphere.

Upon leaving the column and again entering the ordinary atmosphere, the absence of the stimulus of so much oxygen produces a certain degree of lassitude for a time, unaccompanied, however, with any other difficulty. It could not be observed, either in our case or that of the workmen, that in an experience extending over a year, any effect prejudicial to the health or constitution was produced.

I have already alluded to the extension of the concrete filling below the bottom of the column, and to its lateral expansion beyond its vertical lines. I believe that this has not been used in any similar work, and as it so much increases the supporting power of the column at its greatest depth, and at so small an expense, I have thought that a more particular description of the method adopted by me would be interesting, particularly as it has been questioned by those who have not tried it, whether this extension and expansion was practicable in all situations.

I will first call your attention to the increased support which this expanded base furnishes.

In a column of three feet diameter, with an expanded iron base of six feet, and a further expansion of the concrete filling to ten feet diameter, and driven forty feet into the earth, the external frictional support would be about 180 tons, and the support from the bottom areas from four to eight hundred tons.

This increased support of three to seven hundred tons, would be obtained by an expenditure of less than a hundred dollars.

The extension of the concrete filling downwards, must, of course, be proportioned to its lateral expansion; that is, the thickness of the concrete beneath the outer periphery of the column must be increased, to bear the increased load which its expansion laterally will enable to be placed on the column.

In this connection, I may remark that the strength of the shell of the iron pile has also a limit; but as that strength will usually be several times greater than the supporting power derived from the earth, it will but rarely become necessary to consider it.

Treated as a column, a tube of three feet diameter, three-fourths of an inch thick, and fifty feet long, between the bridge seat and where it is secured against lateral movement by the surrounding earth, would sustain say seven hundred tons with safety; and, if desired, ribs may be introduced, which, with its flanges, will double or treble this strength.

The method adopted at Harlem at first, was when the column had been driven to the required depth, to drive under its exterior periphery, wooden sheet piles, five feet long, three inches wide and one and a quarter inches thick, on an angle of thirty degrees; but only in sections of a few feet in width at a time. These sheet piles acted merely as a roof or support to the sand above, and if the air presure had been kept up for a day and night beforehand at an extra pressure, it drove out the water from the sand and permitted the excavation to be made in nearly dry earth.

This excavation, however, must be performed rapidly, that is within two or three minutes, or otherwise the pressure of the water and the weight of the superincumbent sand, which then becomes rapidly suffused with water, forces its way through the roof.

If the excavation and concrete filling is quickly done, the operation will always be successful. A little experience on the part of our workmen enabled them to judge whether the earth was in proper condition to give success. This operation was confined to a small section at a time, and these sections were never undertaken contiguous to each other, but always on opposite sides of the circumference of the column.

When a ring of concrete had been put in by the means above stated, it formed an actual prolongation of the depth of the column, and that part of the concrete under it could be extended several feet deep without encountering the water.

The material which was encountered at Harlem in several places, was very fine sand, which is the worst that could have been met with, and therefore I feel assured that this method may be practiced under almost any circumstances that would be likely to occur.

Towards the end of our operations our men became so expert that they would extend the concrete three feet beyond and four feet below the iron column, in fine sand without the use of roofing.

It has been stated that our hydraulic cement will not set in the concrete in these columns. While this is true of concrete, put in large masses at a time, when properly put in, the concrete will set

even better than in open air. The cause of this failure is, that the surface sets with extraordinary rapidity in the highly condensed air, and when the concrete is put in, in large masses, the moisture from the interior has no opportunity to escape, and, consequently, it remains in a pasty condition.

To remedy this I used small tubes of iron, passing down through the concrete, vertically, to beneath the bottom, and perforated on their sides, by means of which a film of air was interposed between the exterior water and the concrete, and the condensed air was circulated through the mass of the latter and absorbed its excess of water, and caused the whole mass to set quickly and very strong.

Difficulties have heretofore been met with in the placing of the column and keeping it accurately in position.

There is no occasion for this. If practicable, they should be driven from a platform and not from a float. The bottom of the column should be placed in its precise position, and if care is exercised to keep it plumb while being driven, there is no danger of its divergence at the bottom.

In several cases we encountered the edges of sloping rocks, which did not change the exact perpendicular descent of the column. The columns at Harlem were driven with almost perfect accuracy; none of them varied one inch from the position designed.

The delay and difficulty of driving them through logs and boulder-rocks is much less than might be anticipated. In one of the columns a succession of boulders was encountered, over thirty in number, nearly all of which were so large or so situated, that they had to be cut through. These very unusual obstructions did not delay the sinking of this column more than a fortnight.

In another case a column was driven through the hull of a sunken vessel, when the timber was extraordinarily tough and strongly bolted. This delayed us but two days. We also cut off some very large oak logs.

The cost of removing the excavation from one of the columns was seventy-five cents per cubic yard, though generally it cost double that sum. The indraft of sand was about three times the displacement of the column; though as we acquired experience, we were enabled to materially lessen this indraft.

The force employed upon the various parts of the work was as follows:—

1 Foremen and 3 men within the column.

1 Superintendent, 2 riggers and 4 laborers outside.

1 Engine-man and 1 fireman.

The machinery and tools employed did not cost more than $15,000, and the platform and sheds as much more. But a much larger and better adapted plant ought generally to be provided.

The time occupied in the driving of the columns an average depth of twenty-five feet below the bed of the river, in sand, gravel, boulders and timber, expanding and sealing the bottom with concrete, was from seven to twenty days for each column. The lowest of these figures representing the time required for those presenting but few difficulties or obstructions, and the highest number of days the excess of time required to overcome the most serious difficulties.

It has been stated that generally the water was expelled from the column through its open bottom, but sometimes the earth became so compacted by subsidence, or a stratum of clay was encountered, which presented a barrier to the passage of the water in that direction. In this case it was forced up through a syphon-pipe within the column, and discharging through a curved pipe into the atmosphere near the bottom of the air-lock.

This syphon-pipe was also used as a sand-pump to discharge the material from the column. Although successful and economical, it was attended with too much hazard to the lives of the men within the column to warrant its use.

The rapid consumption of the oxygen of the air within the column by the use of lamps, led us to devise plans for sending down through the bull's eye glasses, reflected light. For this purpose we used common mirrors, which reflected the sun's rays; and the success of that plan demonstrated that sufficient light could be furnished artificially and reflected into the column, to answer all requirements.

During the winter, when the thermometer fell below zero, the workmen complained of cold, and the air forced into the column was first heated by the exhaust steam, discharged into a register.

In midsummer they suffered from the intense heat, which rose to above 100°, and this was moderated by allowing the spray from a stream of water to fall upon and be evaporated from the sides of the cast iron column above the water. A reduction of from 10 to 15 degrees was thus effected.

I have understood that elsewhere work on such columns had to

be abandoned during the day, from the excessive heat within the column.

The condensation of the air converts the latent heat in the atmosphere into a specific heat, and raises its temperature ten or fifteen degrees, and when the air was again allowed to escape, it brought the thermometer, placed in the line of its exit, nearly down to the freezing point.

The capacity of the atmosphere for the retention of moisture was beautifully illustrated within the column, when from any cause the pressure of the air was suddenly relieved, which produced a dense fog and deposition of moisture.

The power used for condensing the air was an imperfect six-horse engine, and sometimes the operation in hand required more power than this engine could furnish. We therefore sealed the top and bottom of one of the empty columns, and kept it charged with air at a high pressure, and by means of a flexible pipe to the column which was being sunk, we availed of this additional power.

This reservoir of power was of great advantage in some of the operations, as we could charge the column a second time instantly with air, after it had ceased sinking by the ordinary process, and repeat the sinking process, while the earth adjacent to it was still loose; and it also gave us complete command of the descent of the column, so that we could at any instant check it at the desired point.

The mass of metal which we were handling weighed nearly fifty tons, and with this adjunct we could almost instantly destroy its gravity or restore it at will. It was grand to witness this huge iron tube commencing its descent into the river, at first slowly, but increasing in velocity by its momentum, until it became almost dangerous, when at the turn of ones wrist it was slowed; again it was started and again arrested, and so, by repeated plunges, until it was finally brought up within an inch of the desired depth.

The Harlem work developed two most important points, not hitherto applied to this system of foundations, viz: the large increase of the supporting power by the expanded concrete base, obtained at an insignificant expense, and the increased effect in driving by the use of the air reservoir, as well as the complete control which it gives on the descent of the column.

The duration of the metal under water has been a subject of inquiry. It has been alledged that certain kinds of cast iron, im-

mersed in acidulated water, undergoes an entire change and loses their strength, and it is inferred that foul and salt water will produce the same change to some extent.

This change is confined to graphitic iron; but when the metal is combined with the carbon, as in the white iron, no such change occurs; and as this combination is more and more complete between the soft and hard irons, so does it become less liable to this change. The white and the mottled irons are subject to a slight oxidation when placed under water, but this corrosion is limited to a trifling depth, and it has been asserted that such slight oxidation prevents any further action on the metal. The result of numerous experiments show that with moderately hard iron, the corrosion in salt water will not exceed one-tenth of an inch in a century, and in fresh water will be inappreciable.

The stability against impact of a pier entirely of iron columns, has been proven by the Chepstow, Charing Cross and other foreign bridges, as well as incidentally by those in this country.

One of the columns which had entered the earth but twelve feet and projected above it about thirty feet, and was not filled, was struck a heavy blow by a steamer without affecting it in the slightest degree, and one of the columns at the Pedee was struck by a raft of timber, one-fourth of a mile long, and nearly the width of the river, without effect.

The column in this case was but eight feet into the sand, and was unfilled.

I am of the opinion that an iron pier, made of two columns, filled with concrete, of eight feet diameter, braced together and protected by a wooden or iron starling, will resist, without the slightest injury to itself, the heaviest blows that a steamer, or drift of timber or ice can give to it.

The rapidity with which such piers may be constructed may be inferred from what has been stated. The piers necessary for a bridge across the Mississippi, may be finished ready for the superstructure, in six months from the day upon which the order for their construction is given, and in two-thirds of that time, if it is desired; and this without regard to the weather or freshets in the river. The latter might produce a few weeks delay and a small additional expense, but neither would be of much consequence.

Mechanics, Physics and Chemistry.

LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 120.)

§ III. *Methods of Precision.*

In § II we described various instruments used in precise measurements, and we will now explain certain methods used, both in making a series of measures on a quantity and in subsequently combining them, so that the final result has the greatest possible accuracy. These methods are designated as *methods of precision.* They can be classed under three heads:—

1. Method of means, or of averages.
2. Method of multiplication.
3. Method of successive corrections.

1. *Method of Means.*—If a series of measurements be taken with an instrument of precision on one and the same quantity, it will be found, when all the measures are made in the same circumstances and with equal care, that they will differ from each other by a *small* amount.

The mean value of all the measures is taken when the probability is even that each measure is more or less than the true measure by *a small quantity.* The mean result in this case is the same as if we added the mean to itself as often as there are separate measures, and divided by the number of measures.

The determination of means is of such constant occurrence in physics, astronomy and chemistry, that the discussion of their *degree of precision* is very important. It is founded on the principle of the theory of probabilities; and we will here give a few of its more important results.

Omitting from consideration gross errors, which can always be avoided by operating with care, the causes of the errors of measurements can be classified in two groups, 1. Constant or regular causes; 2. Irregular or accidental causes; whence we have two kind of errors, 1. *Constant or regular errors,* which are reproduced

when we repeat the observations in the same circumstances; and 2. *Irregular or accidental errors* of which we are not able to get entirely rid; but which, not being subject to any law connecting them with the circumstances of the measurements, occur indifferently to increase or to diminish the true measure.

Examples. A constant cause of error would be an error in the length of the unit used in measuring the base-line of a trigonometric survey. This error will be *regular* and *constant*, and being made every time the unit is applied to the length to be measured, it will be in proportion to this length. It is evident that this error can be allowed for, when we know its amount, and thus our result is the same as if we operated with an accurate unit. As examples of irregular sources of error, we may instance the measurement or sighting of angles in a survey; and the bisection of a line by the reading microscope, or by the telescope of a catheometer.

It is evident that *constant errors* are not eliminated by increasing the number of observations; but the *accidental errors* tend to disappear from the mean as we obtain it from a greater number of measures; for this class of errors are as likely to be in one direction as in another in successive trials, and therefore the mean of an *infinite* number of measurements on the same quantity would give the greatest attainable precision, for the quantities would then exactly balance each other in excess and defect.

To find the degree of precision of a mean we divide the whole series of observations into two or three groups, selected at random, and we calculate for each its mean. If these means differ very little we can regard the observations contained in each group as being sufficiently accurate. To proceed thus, we must have a considerable number of observations, and they must not contain very discordant measures. If the partial means do not thus agree, the precision of the general mean is very doubtful.

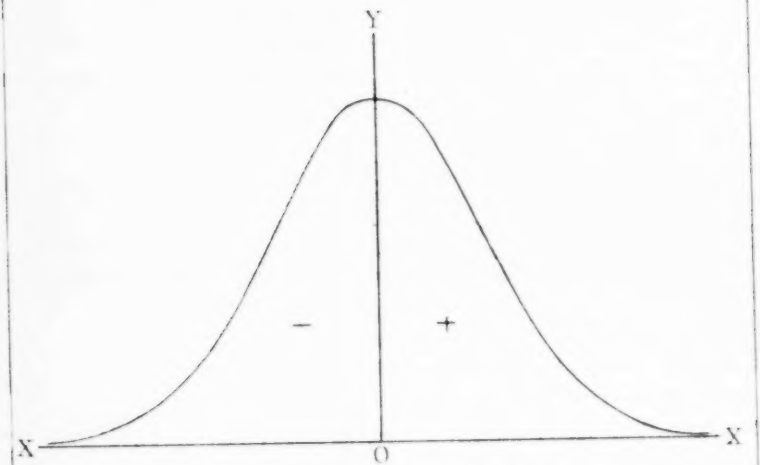
Example. In the observation on the temperature of Providence, R. I., by Prof. A. Caswell, during twenty years, the mean temperature of the first ten years is . . . . . 48°·1 F.

" " second " " " . . . . . 48°·3

Difference, ... 0°·2

The mean of the whole twenty years is . . . 48°·2

This shows that one decade is sufficient to give the mean temperature to within about one-tenth of a degree.



THE PROBABILITY CURVE

It often happens that we find the measures grouped together in series, depending on the periods or on the various circumstances when they were made. It is then indispensable to calculate the partial means of these series, and if there has existed, during the time of the observations, a constant cause of errors, but of variable intensity, it may manifest itself by taking, as above, the means of several groups.

Errors of Observation, called also *residual errors*, are the differences between each particular measure, and the mean of all the measures. These errors are always very small when we operate with care.

The *absolute value* of the quantity sought remaining always unknown, we substitute for it the mean, in the calculation of errors, without which it would be impossible to appreciate them.

When the errors are purely accidental it is found that they can be arranged according to a most remarkable law. If they are grouped by their signs and according to their magnitude, we find that the positive errors and the negative errors are equal in number and in aggregate value, and that they diminish rapidly as we go from the mean, according to a regular law; in other words, the smallest errors are the most frequent and are principally accumulated around their mean value. This remarkable fact is shown in the figure, where, on the left of the axis O Y are placed the differences or errors of observation less than the mean, or —; and on the right those greater than the mean, or +.

Theoretically, this curve, called the *curve of probability*, should be perfectly symmetric and regular. If it departs much from this form it shows that the observations or experiments have not been made with sufficient care, or that their number is insufficient, or that there exists a permanent cause of error arising either from the observer himself (personal equation), or from the manner of operating.

Suppose we have now found a series of measures which, being divided into groups, give as many means which differ by little; that the difference of each mean from the general mean is very small; and, finally, that these errors are distributed about the mean according to the curve of probability; then the cause of the errors is purely accidental, they tend to diappear from the mean, and the *theory of probabilities* gives us the numerical value of the *degree of precision.*

The first principle of this theory is, that *the precision in the mean increases as the square root of the number of observations from*

which it is derived. Thus, the circumstances in both series of observations remaining the same, from sixteen observations we have in favor of the precision of the mean, a probability twice as great as for four observations.

We must now consider another element, which is, the error of each partial measure, or its departure from the mean.

We call the *mean error* not the arithmetical mean of the errors, but *the square root of the mean of the squares of the errors.* Let ε, ε', ε'', &c., ... be the errors of observation, their mean error, e, will be—

$$e=\sqrt{\frac{\varepsilon^2+\varepsilon'^2+\varepsilon''^2+\quad .\quad .\quad .\quad .\quad .}{n}}$$

n being the number of observations.

By means of this *mean error* we can calculate what is called *the probable error*, either of the mean or of a single observation.

The probable error is that quantity which has such a magnitude that there is the same probability of the error, in the quantity determined, being greater as there is of its being less by this quantity.

It is demonstrated that the probable error of a single observation is—

$$\frac{2}{3}e.$$

The probable error of the mean result is—

$$\text{E}=\frac{2}{3}\frac{e}{\sqrt{n}}.$$

We thus see that it diminishes in the inverse ratio of the square root of the number of observations.

We will now show from examples, taken from the appendix to Gerhardt's *Traité Elémentaire de Chimie*, how the foregoing principles and formula can serve to indicate the exactness of a series of measures.

M. Dumas made experiments to determine the composition of water, and to verify the theoretical law of Prout, that all the chemical equivalents are exact multiples of that of hydrogen. The equivalent of oxygen being represented by 100, that of hydrogen should be exactly 12·5. But a series of nineteen experiments gave, after the corrections were made, the following numbers, which we arrange according to their magnitude.

12·472	12·508
·480	·522
·480	·533
·489	·546
·490	·547
·490	·550
·490	·550
·491	·551
·496	·551
	·562

The mean of the numbers is 12·515; the sum of the squares of the errors is 0·0173; the mean error $e = 0{\cdot}030$; the probable error of a single observation is 0·020, and the probable error of the mean result $E = 0{\cdot}0046$. It would appear from this that an error of 0·015 is impossible, and that the equivalent of hydrogen ought to be above 12·500.

But if we observe attentively the table, we will see that the numbers, instead of being accumulated, according to the law of probability, around the mean, tend rather towards the extremes. The means of the two columns are 12·486 and 12·542, which differ too much to accept the hundredths when we unite them. It therefore follows that the method of experiment by which were obtained the numbers, is too gross to decide that the equivalent of hydrogen departs from 12·5, and we cannot therefrom decide against the law of Prout.

We see from this example, taken from *The Theory of Chances*, by M. Cournot, how important it is, before drawing our conclusions, to examine with care the individual observations whence we deduce the mean, so that we may satisfy ourselves of their exactitude.

We often exaggerate the accuracy attained, which is necessarily limited. A quantity cannot be estimated to an indefinite precision even when the observations are indefinitely extended. In the measure of a length, for example, whatever care we may take we can seldom surely rely on more than five figures. Thus, one of the base-lines in the triangulation of France was found to be 6075·9 toises; we find that there can easily occur in this number an error of 0·1. In the estimation of weights there is also a limit of precision which we cannot surpass, whatever may be the accuracy of the balance and the skill of the operator. Here also we cannot rely on more than five significant figures.

Still greater reason is there for care in assuming a certain preci-

sion of result when the measure is the result of several different physical operations, each of which brings with it its own error. In the determination of the number $g = 9^{m}{\cdot}809$, which represents the intensity of gravity at Paris, (or the velocity acquired by a body after falling one second,) the four figures which we have given are those only on which we can rely, and it would be altogether illusory to extend the decimal. If we compare the numbers found by able observers, we find that they differ even in this fourth figure.

Intensity of gravity at Paris.	Length of second's pendulum.
Borda, $9^{m}{\cdot}8089$	$0^{m}{\cdot}99385$
Biot, 9 ·8091	·99387
Bessel, 9 ·8094	·99390

For the length of the second's pendulum we should take $0^{m}{\cdot}9939$, but remembering that we can barely rely upon the result to $\frac{1}{10}$th of a millimetre.

Physicists and chemists have often to estimate the exactness it is possible to attain in the determination of densities and equivalents. By repeating these operations several times in succession, by varying the methods, by taking different specimens of the same body, and finally, by submitting the results to the numerical tests which we have indicated, we arrive at the degree of precision of the results.

We thus find that the number of *certain* figures in this class of determinations is less than we would *à priori* have supposed, and that no more reliance is to be placed in several of the decimals that are usually retained, than if we wrote them down at random. We can often discover this influence of chance in a series of measures. and distinguish those decimal figures which we ought to suppress as being altogether arbitrary, since they are less than the errors of observation. Suppose that we estimate a length which can only be appreciated to a millimetre; if we retain the tenths of millimetre, they will be entirely of an arbitrary value. The figures written in the tenths will be irregular in the successive measures, absolutely, as if we obtained them by drawing at random, out of our pocket, marbles having pasted on them the figures 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. But, as the mean of these ten figures is 4·5, it follows that if we have a great many results, the mean of the figures of tenths of millimetre will be exactly 4·5. And *vice versa*, if in a long series of numbers, given by observation, we find that the mean of all the decimal figures of the last order is 4·5, we can omit them. If it is the same with the figures of the next higher order, we suppress them also and so on.

M. Schrötter determined the equivalent of phosphorus, by weighing the phosphoric acid produced in the combustion of a known weight of that element. These experiments were made upon amorphous phosphorus, previously dried at 150° C., in an atmosphere of carbonic acid or of hydrogen. The transformation of the phosphorus into phosphoric acid, was effected in a combustion tube, through which passed a current of perfectly dry oxygen. After the combustion, the phosphoric acid was sublimed in an atmosphere of oxygen, so as to oxydise any traces of phosphorus acid which might have been produced.

The following are the results:—

Phosphoric acid produced by one part of phosphorus.	2·28909
	·28783
	·29300
	·28831
	·29040
	·28788
	·28848
	·28856
	·28959
	·28872
Mean, ...	2·28919

We find that the sum of the figures of the last column on the right is 46, the mean of which is 4·6, since there are ten results. In the same manner the mean of the next column, to the left, is 4·4. We therefore retain only the first three decimal figures, the remaining two being solely due to hazard. This done, if we calculate the error of each observation, or the departure from the mean, we will find that the sum of the squares of these errors is 0·000022; the mean error $e = 0{\cdot}0015$, the probable error of a single observation is 0·001, and the probable error of the mean is $\text{E} = 0{\cdot}0003$.

We can therefore admit that one part of phosphorus gives 2·289 of phosphoric acid, and that the error of this result certainly does not exceed six times the probable error, that is to say, 0·002. The corresponding equivalent of phosphorus is 31·027, and its probable error = 0·004, which is expressed thus—

$$31{\cdot}027 + 0{\cdot}004.$$

But that supposes that the analyses are only effected with accidental

errors, while it may readily happen that they are subject to a constant error. It would then follow that the figure of the hundredths could not be regarded as certain; therefore M. Schrötter adopts simply 31 as the final result of his researches.

It is from the constant errors existing that we may err in the conclusions that we prematurely draw from the calculation of the mean of the probable errors. And it often happens that subsequent observations show that the mean adopted at first is affected with an error far exceeding the probable error which we attributed to it.

It is a characteristic of the arithmetical mean, that it makes *the sum of the squares of the residual errors a minimum.*

To illustrate this principle geometrically, suppose that several observations, made to determine the position in space of a point, A, give several positions around the true point, A. Connect the points given by observation by straight lines; then the centre of figure or centre of gravity of the polygon, which is formed by joining these points, is evidently the most probable position of A. Draw lines from the angles of the polygon to its centre of figure; then these lines will represent the several errors of the observations. Now, it is a property of the centre of gravity of such a polygon, that the sum of the squares of these lines is less than the sum of the squares of similar lines drawn to any other point within the polygon. Therefore, *if the sum of the squares of the errors is the least possible, we have the nearest mean we can obtain from the observations.*

This is the fundamental principle of the celebrated theorem of *Least Squares*, of Gauss and of Legendre, which has rendered such inestimable service to physics and astronomy.

Suppose that, instead of having to determine, as in the above examples, a single unknown quantity—which is the mean of the several observations,—we propose to determine several unknown quantities entering as functions in equations. As observations or experiments give the known quantities of these equations, we will have as many equations as there are observations. Having, for example, two quantities to be determined, x and y, suppose that we have made three observations, giving three equations. The values of x and y deduced from two of these equations, will not generally satisfy the third. The difficulty consists in using all the equations at once, so that we can deduce from them a series of values which will satisfy, in the most accurate manner possible, all the equations. The

theory of the method of least squares shows, in order that this may happen, that the sum of the squares of the errors must be a minimum.

In a series of observations or experiments, let us suppose that the errors committed are denoted by e, e', e'', &c., and suppose that by means of the observations, we have deduced the equations of condition—

$$\left.\begin{array}{l} e \;\; = h + a\,x + b\,y + c\,z + \&c. \\ e' \;\; = h' + a'\,x + b'\,y + c'\,z + \&c. \\ e'' \;\; = h'' + a''\,x + b''\,y + c''\,z + \&c. \\ e''' = h''' + a'''\,x + b'''\,y + c'''\,z + \&c. \\ \qquad \&c. \qquad\quad \&c. \qquad\quad \&c. \end{array}\right\} (1.)$$

Let it be required to find such values of x, y, z, &c., that the errors e, e', e'', e''', &c., with reference to all the observations shall be the least possible.

If we square both members of each equation, in group (1), and add them together, member to member, we shall have—

$$\begin{aligned} e^2 + e'^2 + e''^2 + \&c. &= x^2 (a^2 + a'^2 + \&c.) \\ &+ 2\,x \left\{ (a\,h + a'\,h' + \&c.) + a\,(b\,y + c\,z + \&c.) \right. \\ &\left. + a'\,(b'\,y + c'\,z + \&c.) + \&c. \right\} + \&c., \end{aligned}$$

an equation which may be written—

$$e^2 + e'^2 + e''^2 + \&c. = u = P\,x^2 + 2\,Q\,x + R + \&c.$$

Now, in order that $e^2 + e'^2 + \&c.$, or u, may be a minimum, it is necessary that its partial differential co-efficients, taken with respect to each variable, in succession, should be separately equal to O. Hence,

$$\begin{aligned} \frac{d\,u}{d\,x} = p\,x + q = 0, \text{ or } & x\,(a^2 + a'^2 + \&c.) \\ &+ a\,h + a\,h' + \&c. + a\,(b\,y + c\,z + \&c.) \\ &+ a'\,(b'\,y + c'\,z + \&c.) + \&c. = O\,; \end{aligned}$$

and similar equations for each of the other variables. Hence, we deduce the principle, that, in order to form an equation of condition for the minimum, with respect to one of the unknown quantities, as x for example, we have simply to multiply the second members of each of the equations of condition by the co-efficient of the unknown quantity in that equation, then take the sum of the products, and place the result equal to O. Proceed in this manner for each of the

unknown quantities, and there will result as many equations as there are unknown quantities, from which the required values of the unknown quantities may be found by the ordinary rules for solving equations.

Let it be required, for example, to find from the equations—

$$\left.\begin{aligned} 3 - x + y - 2z &= 0 \\ 5 - 3x - 2y + 5z &= 0 \\ 21 - 4x - y - 4z &= 0 \\ 14 + x - 3y - 3z &= 0 \end{aligned}\right\} \quad (2),$$

such values of x, y, and z, as will most nearly satisfy all of the equations.

[It is to be remarked, that we must necessarily admit that these equations already approximate closely in value, that is to say, that the values of x, y, and z deduced from the three first will satisfy approximately the third; without this, the problem is absurd, and the observations which have given these equations are unworthy of confidence.]

"Following the rule, and multiplying the first member of each equation by the co-efficient of x in that equation, we get the products—

$$\begin{aligned} &- 3 + x - y + 2z \\ &- 15 + 9x + 6y - 15z \\ &- 84 + 16x + 4y + 16z \\ &\quad 14 + x - 3y - 3z, \end{aligned}$$

and placing their algebraic sums equal to O, we have—

$$27x + 6y - 88 = O, \quad . \quad . \quad . \quad . \quad (3.)$$

Proceeding in like manner with respect to the unknown quantities y and z, we obtain the equations—

$$\begin{aligned} 6x + 15y + z - 70 &= O, \quad . \quad . \quad . \quad (4.) \\ y + 54z - 107 &= O, \quad . \quad . \quad . \quad . \quad (5.) \end{aligned}$$

Combining equations (3), (4), and (5), we find—

$$x = 2{\cdot}4702,\ y = 3{\cdot}5507, \text{ and } z = 1{\cdot}9157,$$

which most nearly satisfy all of the equations in group (2).

To show the practical application of this principle, we will suppose that it is required to investigate the values of a constant in an equation, by means of several independent experiments.

It is demonstrated from theory that the length of the pendulum which beats seconds, in any latitude, is given by the formula—

$$L = x + y \sin.^2 l, \quad . \quad . \quad . \quad . \quad (6,)$$

in which L denotes the length of the pendulum; l the latitude of the place on the surface of the earth, and x and y are constants to be determined. In consequence of errors incident to observation, the values of x and y cannot be accurately determined by means of a single observation; taking the *metre* (denoted by m) as the unit of measure, suppose that the length of the second's pendulum has been measured in six different places, whose latitudes are known, and that the following equations have been deduced:

$$\left.\begin{aligned} e' &= x + y \times 0^{m}.3903417 - 0^{m}.9929750 \\ e'' &= x + y \times 0^{m}.4972122 - 0^{m}.9934620 \\ e''' &= x + y \times 0^{m}.5667721 - 0^{m}.9938784 \\ e^{iv.} &= x + y \times 0^{m}.4932370 - 0^{m}.9934740 \\ e^{v.} &= x + y \times 0^{m}.5136117 - 0^{m}.9935967 \\ e^{vi.} &= x + y \times 0^{m}.6045628 - 0^{m}.9940932 \end{aligned}\right\} \quad (7.)$$

Applying the rule already deduced, to these questions, we find the equations—

$$6x + y \times 3^{m}.0657375 - 5^{m}.9614793 = 0, \quad . \quad . \quad (8),$$
$$x \times {}^{m}.0657375 + y \times 1^{m}.5933894 - 3^{m}.0461977 = O, \quad (9.)$$

Combining equations (8) and (9), we obtain—

$$x = 0^{m}.9908755, \; y = 0^{m}.0052942.$$

Substituting these in equation (6), it becomes—

$$L = 0^{m}.9908755 + 0^{m}.0052942 \; sin.^2 l, \quad . \quad . \quad (10.)$$

By means of formula (10), the length of the second's pendulum may be found, by computation, at any place whose latitude is known. In like manner, the method of least squares may be applied to a multitude of similar cases." (See art. *Least Squares, Dict. of Mathematics*, by Davies and Peck, N.Y., 1865.)

It is impossible, in lectures of this character, to give more than an idea of this fertile principle of *Least Squares*. The reader is referred to the following works for a full discussion of the method. *Méthode des moindres carrées; Mémoires sur la combinaison des observations, par Ch. Fr. Gauss, traduit par J. Bertrand*, Paris, 1855; also *Method of Least Squares*, by Prof. William Chauvenet, in the appendix to his *Spherical and Practical Astronomy*, Phila., 1863. From this work the figure of the probability curve is taken.

2. *Method of Multiplication.*

The method of multiplication consists in measuring a known multiple, by n, of the quantity to be determined, and then dividing the result by n. By this method the error, committed in the direct measure, is divided by n.

Example 1. To find the diameter of a fine metallic wire, we wrap a certain number of turns, say 200, of the wire on a metal cylinder, taking care to press the coils until all are in contact. Measure the length of the 200 coils, and dividing this length by 200, we have—supposing all the coils are formed of wire of the same diameter—the diameter of the wire to the $\frac{1}{200}$th of the error committed in the measure of the length of the 200 coils. Suppose, for example, we have made an error of $\frac{1}{20}$ inch in measuring the length of 200 coils; then the error in the determination of the diameter of the wire is $\frac{1}{200}$ of $\frac{1}{20}$ or the $\frac{1}{4000}$th of an inch.

Example 2. By a similar operation we determine, with great accuracy, the distance between the contiguous threads (called *the pitch*) of a micrometer screw.

Example 3. Saxton's Reflecting Comparator is a beautiful illustration of the principle of multiplication, in which the direct measure is a very large multiple of the quantity whose value we desire.

Example 4. We may obtain a very accurate determination of the weight of a body, with a balance with equal arms, by equilibrating the body with shot, &c., placed in the other pan; then placing the body in the same pan with the shot, &c., we obtain in the other pan, in shot, *twice* the weight of the body. We now add the shot of twice the weight of the body, to the pan containing the body, and on again equilibrating, we have in the pan opposite the body, a weight of shot equal to *four times* the weight of the body, and so on. We finally have in a pan a known multiple, by n, of the weight of the body, which, divided by n, gives the weight we seek.

Example 5. *The Method of Repetition.*—Describe the method with the aid of diagrams. It is a very ingenious application of the method of multiplication to the measurement of angles, by means of the *repeating circle*, invented by Tobias Mayer, of Göttingen, in 1762, and subsequently improved by Borda, of Paris.

3. *Method of Successive Corrections.*

This method, used frequently in astronomy, is also often employed in researches in Physics. We will explain it by an exam-

ple (from *Daguin's Traité de Physique*, vol. i., page 30). Let it be proposed to determine the capacity of a ground glass-stoppered flask. If we knew the weight of the water at 4° C., which the flask holds, then just as many grammes as there are in this weight, are there cubic centimetres in the flask; for a gramme is the weight of one cubic centimetre of pure water at 4° C. It is, therefore, required to determine the weight of the flask-full of water at 4° C., which we suppose is the temperature when the experiment is made. We first weigh the flask, full of air, then full of water at 4° C. Let p and P be the two weights, respectively. P—p will represent the weight of the water, if the flask, during the first weighing, had contained no air, whose weight is added to that of the flask. The value P—p is therefore too little by the weight of that quantity of air. Suppose that the water at 4° C., weighs n times as much as an equal volume of air, taken at the same atmospheric pressure and temperature as in the experiment. We will see further on how this number n is obtained. The weight of the air which fills the flask will then be $(\text{P}-p)\frac{1}{n}$, if we suppose for the moment that P—p is the exact weight of the water. Then the weight of the water which fills the flask will be—

$$(\text{P}-p)+(\text{P}-p)\frac{1}{n}=(\text{P}-p)\left(1+\frac{1}{n}\right), \quad . \quad . \quad (1.)$$

This expression, however, does not represent the exact weight of the water, because the term (P—p), and consequently the term $(\text{P}-p)\frac{1}{n}$, are too small. But the error which exists in value (1) is less than that which affects the value P—p. If we now employ the value (1) to calculate the weight of the air, this weight will be—

$$(\text{P}-p)\left(1+\frac{1}{n}\right)\frac{1}{n};$$

and the weight of the water will become—

$$(\text{P}-p)+(\text{P}-p)\left(1+\frac{1}{n}\right)\frac{1}{n}=(\text{P}-p)\left(1+\frac{1}{n}+\frac{1}{n^2}\right), \quad . \quad (2;)$$

a value which is a still greater approximation to the true value, and which, multiplied by 1 : n, will give the weight of the air with still greater precision.

By adding this weight to P—p, we will have for the weight of the water—

$$(P-p)\left(1+\frac{1}{n}+\frac{1}{n^2}+\frac{1}{n^3}\right);$$

nearer than any of the preceding values. By continuing in this manner, we can carry the approximation as far as we desire.

(To be continued.)

FLAME REACTIONS.

By Prof. Bunsen.

Translated by Prof. Charles F. Himes, Ph. D., Dickinson College, Carlisle, Pa.

(Continued from page 130.)

I.—Behavior of Tellurium Compounds.

A. *Flame coloration*, in the upper reducing flame, pale blue, whilst the oxidizing flame above appears green.

B. *Volatilization* unaccompanied by any odor.

C. *Reduction incrustation*, black, with dark brown coating, dull or brilliant; heated with concentrated sulphuric acid gives a carmine red solution.

D. *Oxide incrustation*, white, scarcely or not at all visible; protochloride of tin colors it black, by reason of separated tellurium; nitrate of silver, after ammonia has been blown upon it, yellowish-white.

E. *Iodide incrustation*, dark brown, with brown coating; disappears transitorily when breathed upon; disappears easily, permanently, when ammonia is blown upon it, and does not reappear upon gently warming it, but does over hydrochloric acid; blackened by protochloride of tin.

F. *Sulphide incrustation*, dark brown to black; does not disappear when breathed upon; dissolves in sulphide of ammonium blown upon it, and reappears upon warming, or upon drying it by blowing upon it.

G. *On a charcoal rod with carbonate of soda*, gives telluride of sodium, which, when moistened upon a silver coin, produces a black spot, and if the test specimen contains much tellurium, with hydro-

chloric acid, diffuses an odor of telluretted hydrogen with the separation of black tellurium.

II.—Behavior of Selenium Compounds.

A. *Flame coloration*, pure azure-blue.

B. *Volatilizes*, burning, with the diffusion of the characteristic selenium odor.

C. *Reduction incrustation*, brick-red to cherry-red; at one time dull, at another brilliant, gives when heated with concentrated sulphuric acid, a dirty green solution.

D. *Oxide incrustation*, white; brick-red from separated selenium when protochloride of tin is dropped upon it; the red color is rendered darker by hydrate of soda; with nitrate of silver the oxide incrustation gives a white, scarcely visible coloration, which disappears when ammonia is blown upon it.

E. *Iodide incrustation*, brown, contains some reduced selenium, and therefore cannot be made to disappear completely, either by breathing upon it or by blowing ammonia upon it.

F. *Sulphide incrustation*, yellow to orange-red, insoluble in water, soluble in sulphide of ammonium. Since the sulphide incrustation is produced from the iodide incrustation, it consequently also contains some reduced selenium, and therefore does not give very clear reactions.

G. *Reduction with carbonate of soda on the charcoal rod* gives selenide of sodium, which produces with a drop of water a black spot upon a silver coin, and moistened with hydrochloric acid, if the quantity of the substance was not too small, diffuses the odor of selenuretted hydrogen with the separation of red selenium.

III.—Behavior of Antimony Compounds.

A. *Flame coloration*, upon treatment in the upper reducing flame, greenish pale, accompanied by no odor.

B. *Reduction incrustation*, black, at one time dull, at another brilliant.

C. *Oxide incrustation*, white; gives, when moistened with perfectly neutral nitrate of silver and then treated with ammonia, blown upon it, a black spot of antimonate of sub-oxide of silver, which does not disappear when ammonia is dropped upon it. If the incrustation is first treated with bromine fumes, the reaction will not take

place, by reason of the oxidation of the antimonious acid* to antimonic acid. The incrustation is not affected by protochloride of tin, with or without hydrate of soda.

D. *Iodide incrustation*, orange-red, disappears when breathed upon, reappears upon blowing it dry, or gently warming it; disappears permanently when ammonia is blown upon it, reappears again upon treatment with hydrochloric acid vapor. In other respects, gives the same reactions as the oxide incrustation.

E. *Sulphide incrustation*, orange-red, even the coating is made to disappear with considerable difficulty by blowing sulphide of ammonium upon it; upon blowing it dry, it reappears again; insoluble in water.

F. *On charcoal rod with carbonate of soda* does not give a mass which tarnishes silver, but a brittle, white crystalline metallic grain.

IV.—Behavior of Arsenic Compounds.

A. *Flame coloration*, in upper reducing flame, pale blue, with the diffusion of the well known arsenic odor.

B. *Reduction incrustation*, black, dull or brilliant, with brown coating.

C. *Oxidation incrustation*, white; when brushed with perfectly neutral nitrate of silver, and ammonia then blown upon it, gives a lemon-yellow precipitate, which can be made to disappear by blowing ammonia upon it. Besides the yellow precipitate, usually a brick-red one of arsenate of silver occurs, which appears alone if the incrustation is previously treated over vapor of bromine. Protochloride of tin, with and without hydrate of soda, does not change it.

D. *Iodide incrustation*, egg-yellow, disappears transitorily when breathed upon; disappears permanently when ammonia is blown upon it; reappears unchanged by means of hydrochloric acid fumes.

E. *Sulphide incrustation*, lemon-yellow, easily made to disappear by blowing sulphide of ammonium upon it, reappears when dried by blowing, or upon warming; insoluble in water, and does not disappear when breathed upon.

F. *Reduction on charcoal rod* produces no metallic grain.

V.—Behavior of Bismuth Compounds.

A. *Flame coloration*, bluish, not characteristic.

B. *Reduction incrustation*, black, dull or brilliant; coating bistre.

* Antimonate of ter-oxide of antimony.—(Tr).

C. *Oxide incrustation*, faintly yellowish; unchanged by nitrate of silver either alone or with ammonia; with protochloride of tin alone, also gives no reaction, but after the addition of hydrate of soda, becomes black by reason of the binoxide of bismuth formed.

D. *Iodide incrustation* is very characteristic, and remarkable for the beauty and variety of its shades of color; it is brown to dark brown, with a trace of lavender blue; the coating passes through flesh-red to aurora-red; it disappears readily when breathed upon, and reappears when dried by blowing upon it. The incrustation, when ammonia is blown upon it, passes through aurora-red to egg-yellow, and reappears, when dried by blowing upon it or upon warming, with chestnut-brown color. Toward protochloride of tin and hydrate of soda, it behaves as the oxide incrustation.

E. *Sulphide incrustation*, umber-brown, with coffee-brown coating, does not disappear when breathed upon, and is insoluble in sulphide of ammonium.

F. *On charcoal rod with carbonate of soda* the compounds of bismuth are reduced to a metallic grain, which, when rubbed, gives brilliant yellowish metallic spangles, which are soluble in nitric acid. The solution gives with protochloride of tin and hydrate of soda, black binoxide of bismuth.

VI.—Reaction of Mercury Compounds.

A. *Metallic incrustation*, mouse-grey, diffused disconnectedly over the whole porcelain capsule. In order to obtain slight traces of mercury reduced, the dry test specimen is mixed with a mixture of carbonate of soda and nitrate of potash, and placed in a test tube of thin glass, 5—6 millimetres wide, 10—20 millimetres long, which is heated on a platinum wire in the flame, whilst the convex bottom of the porcelain capsule, filled with water, touches the upturned mouth of the test tube. If the quantity of mercury is more considerable, the metal is obtained in the form of globules, recognizable under a lens, which unite to form larger globules when brushed with moistened blotting paper.

B. *Oxide incrustation* cannot be produced.

C. *The iodide incrustation* is obtained in the following way: The metallic incrustation is breathed upon, and then placed upon the mouth of a wide-necked bottle, Fig. 8, containing moist bromine. It first becomes black, and thereupon disappears, though only *after considerable time*, being converted into bromide of mercury. If the

capsule is now placed over fuming hydriodic acid, the very characteristic carmine-red incrustation of iodide of mercury appears, often still accompanied by the yellow incrustation of subiodide, neither of which disappears when breathed upon, nor when ammonia is blown upon it.

D. *Sulphide incrustation*, black, does not disappear when breathed upon, and insoluble in sulphide of ammonium.

E. *On charcoal rod with carbonate of soda* gives no reaction.

VII.—Behavior of Thallium Compounds.

Since even several millionths of a milligramme of thallium can be recognized by means of the spectroscope, a case seldom occurs in which this metal is detected in any other way. I give the following reactions, therefore, only for the sake of completeness.

A. *Flame coloration*, bright grass-green.

B. *Metallic incrustation*, black, with coffee-brown coating.

C. *Oxide incrustation*, colorless; unchanged by protochloride of tin alone, or with hydrate of soda; also no reaction with nitrate of silver, either with or without ammonia.

D. *Iodide incrustation*, lemon-yellow, does not disappear when breathed upon, nor when ammonia is blown upon it; insoluble in ammonia.

E. *Sulphide incrustation*, obtained from the oxide incrustation, black, with livid coating, insoluble in liquid sulphide of ammonium.

F. *On charcoal rod with carbonate of soda*; reducible to a white ductile metallic grain, which becomes rapidly covered with oxide in the air, and is with difficulty attacked by hydrochloric acid.

Besides the metals belonging to group A 2, which have been considered, there are two others, tin and molybdenum, which could be assigned to the same group. The reduction of these two substances cannot, however, be effected in cases of all compounds, and on account of the slight volatility of these metals is accomplished with difficulty, so that it is better to assign them to groups B 2, B 1 *b*, since they can be most readily recognized by the characteristic reactions of these groups.

(To be continued.)

METHOD OF QUALITATIVE ANALYSIS OF ANIMAL AND VEGETABLE COLORING MATTERS BY THE SPECTRUM MICROSCOPE.

By H. C. Sorby, F. R. S., &c.

(Continued from page 61.)

From the Proceedings of the Royal Society, No. 92.

In spectra showing one absorption-band, there is very commonly a general absorption, extending from it towards the blue end; whereas it so seldom extends towards the red end that it is doubtful if it ever occurs in substances, undoubtedly not a mixture of two colors. It can, however, so easily occur in mixed colors, that any substance giving rise to such a spectrum is probably a mixture. Many illustrations might be given, but I will select Brazil-wood, and the same artificially mixed with the color of beet-root. Adding bicarbonate of ammonia to both, we have—

*

Brazil-wood alone ..... $4\frac{3}{4}$—$5\frac{3}{4}$ ... 7

*

Brazil-wood and beet-root $3\frac{1}{2}$ ... $4\frac{5}{8}$—$5\frac{3}{4}$ 8

Here, then, the shading below the absorption-band from $3\frac{1}{2}$ to $4\frac{5}{8}$ is evidence of the second color, and if such a mixture had occurred naturally, its mixed character might easily have been overlooked. I have found many cases similar to this, and had proved that they were mixtures, before I was aware that the spectra indicated it. If these very common facts turn out to be general laws, we might thus detect at once the presence of as many as three different substances, or, at all events, might learn what further examination was desirable.

15. *Sulphite of Soda.*

Sulphite of soda is a most valuable reagent, and its action very remarkable. It enables us to divide colors into three groups, according as it produces a change in an ammoniacal, or acid solution, or in neither. The action is related in a very simple manner to the spectra. Having added an excess of ammonia, there may be a well-marked broad absorption over more or less of the red, orange, yellow, and upper green; and above this a clear, transparent space, limited by a variable amount of absorption, extending downwards from the extreme blue. Fig. 2 will illustrate my meaning. In the case of one group of colors, the addition of sulphite of soda almost immediately removes the detached, broad absorption in the lower part of the spectrum, but leaves that at the blue end quite unchanged, or only slightly modified by the solution being made more alkaline. If, then, as in the case of magenta, there is no absorption at the blue end, sulphite of soda makes the solution quite colorless;

whereas if the blues are absorbed, as in the case of the ammoniacal solutions, of the color of red roses, and some species of *Dianthus*, it changes the color from green to yellow. If the absorption extends continuously down from the extreme blue to the orange, as often happens when ammonia is added to yellow colors, sulphite of soda produces no change. It is only when there is a more or less perfect *division* between the upper and lower absorption, that it has any effect; and then it simply and entirely removes the lower absorption. Some colors are changed immediately, even when a very small quantity of sulphite is added; but others require more, and change gradually, though still very soon.

16. *Groups A, B, and C.*

Colors which are thus altered when the solution is ammoniacal, constitute my group A. Frequently, however, sulphite of soda does not remove the detached absorption when excess of ammonia is present, but does so when there is an excess of citric acid. These constitute my group B. As in the other group, any absorption which extends continuously from the extreme blue end is not altered, but the detached absorption in the green is almost immediately removed; and therefore a deep pink or red solution may at once become quite colorless, or only a very pale yellow; and in many cases this residual color is due to some yellow coloring-matter mixed with the other. I have never seen a color which was changed by sulphite when alkaline, and not when acid; and thus citric acid never restores the color when it is added to the changed ammoniacal solution. Excess of ammonia usually restores the faded acid solution to nearly the original color, and it is therefore not a case of actual decomposition, but merely the result of some remarkable molecular change. A third group of colors consists of those which are not almost immediately changed by sulphite of soda, when either alkaline or acid; and these I call group C. Some of them may fade on keeping several hours, and some do not fade even in several days, but they cannot thus be divided into two definite groups. When thus faded, ammonia does not restore the color; and therefore it is evidently the effect of decomposition, and not like the mere molecular change met with in group B.

On the whole, the groups A, B and C are remarkably distinct. There are, indeed, a few cases where the change takes place somewhat slowly; and a few scarlet colors do not show very distinctly the characteristic peculiarities of either B or C; but there are other very strong reasons for believing that some of these are really mixtures of different groups. Even if it should be found that perfectly simple coloring-matters may have, as it were, intermediate characters, such appear to be so rare that practically they may be classed with mixtures, until some reason be found for classing them together as exceptions.

These reactions of sulphite of soda are so much interfered with by the presence of alcohol, that it should never be employed as a solvent, unless the substance is insoluble in water; and then it should be diluted as much as possible, since the ordinary spirit of wine with an equal quantity of water is the extreme strength admissible, and even that very much delays the reaction. The effect of various other reagents is also sometimes very different, according to the nature of the solvent.

The three groups A, B, and C differ in other particulars. It is easy to change A or B into C by various reagents which produce decomposition, but I do not know a case where C can be changed into A or B. Caustic alkalies usually soon decompose colors belonging to group A, when dissolved in water, but act slowly on those of groups B and C. Usually colors of group C are far more permanent than those of groups A and B, and to it belong most of the vegetable colors used in dyeing, and nearly all yellows.

17. *Other Reagents.*

Boracic Acid.—The chief value of this reagent is, that it gives nearly the same spectrum as that of a neutral solution when added after the addition of a slight excess of ammonia. It should therefore be well fused in a platinum crucible and recrystallized, so as to be quite free from any stronger acid.

Sulphate of Iron.—Sulphate of the protoxide of iron is chiefly useful as a deoxidizing agent, in the case of blood and a few analogous substances, taking care to have citric acid present to prevent the precipitation of the oxide by ammonia.*

Alum.—Alum has a remarkable influence on some colors, and it has the property of gradually restoring many after they have passed into the faded modification. Many colors also may be kept for a long time dissolved in a strong solution, sealed up in tubes; and it is occasionally an excellent solvent for substances insoluble in either water or alcohol. The chief objection to it as a reagent is that the spectra are so much influenced by the presence of ammonia, even when neutralized by an acid, that it is almost impossible to compare together different substances under exactly the same conditons.

Iodine and Bromine.—Iodine dissolved in alcohol, and bromine in water, are useful in producing decompositions, which may differ very considerably in colors which are otherwise very similar; as, for example, the yellow coloring-matters of the root of rhubarb and of turmeric. The iodine or bromine should be added in sufficient quantity, and then ammonia used to remove the excess, and thus avoid the effect of their own color. The solution may then be made acid with citric acid, and should in both cases be compared with another tube to which no iodine or bromine has been added.

* See Stokes's Paper, Proceed. Roy. Soc. vol. xiii. (1864) p. 355.

Hypochlorite of Soda.—This reagent, with or without the addition of citric acid, is sometimes useful, as for instance in detecting the adulteration of rhubarb with turmeric; but generally its action is too powerful and too uniform.

Permanganate of Potash.—This also usually acts too powerfully on coloring-matters. The excess can easily be removed by sulphite of soda, which makes an alkaline solution pale yellow, but an acid solution quite colorless.

18. *Grouping of Colors.*

Having now considered some of the chief peculiarities of the most useful reagents, I proceed to describe what appears to me the most convenient method of dividing coloring-matters into groups and subgroups, so as to enable us to ascertain the nature of any particular substance under examination. The number of distinct colored compounds met with in different plants, is so great, that some such classification is imperative. In the first place, we cannot do better than divide them according as they are soluble in water or alcohol. This may be looked upon as a *chemical* division, and is very useful in practice. Thus:

Soluble in water and not precipitated by alcohol . .	Division 1.
Soluble in water and precipitated by alcohol . . .	" 2.
Insoluble in water but soluble in alcohol	" 3.
Insoluble both in water and alcohol	" 4.

Of course cases occur which cannot be unhesitatingly classed with any one of these; but they often form good practical divisions, and necessarily modify the methods requisite for further examination.

19. *Method and Order of Experiment.*

If a color belongs to division 1, a small quantity, sufficient for three or four experiments, should be exposed to the vapor of ammonia in a watch-glass, until there is certainly no longer any *free acid*, and then gently evaporated, so that all excess of ammonia may be lost. If not thus made neutral we might be entirely misled; for some pink colors are blues reddened by an acid. A small quantity should then be dissolved in water in one of the small experiment-tubes and the spectrum observed. If too little color has been added to give the characteristic spectrum, more should be introduced; but if any part is entirely absorbed, the cell should be turned sideways, in order to see whether or no some narrow absorption-band occurs there; and then it may be desirable to remove some of the solution, and fill up the cell with water. As a general rule, so much color should be added as to make the darkest part of the spectrum decidedly shaded, but yet not so black as to hide any narrow bands; and if any occur, the solution should be made of such a strength as to show them to the greatest advantage. This can be easily done, after a little practice, and is made much easier by being able to turn the

tubes sideways. Having noted the spectrum of the neutral solution, a very small quantity of ammonia should be added, and then a decided excess, the spectra being examined to see if there be any difference; for this is very often the case, and very important facts may be overlooked if too great an excess be added at first. The addition of a small bit of sulphite of soda then shows at once whether or no a color belonging to group A is present; and on adding excess of citric acid we may also determine whether it chiefly belongs to groups B or C. Ammonia should then be added in excess, which may or may not restore it to the same state as before the addition of the acid. To another portion of color, carbonate of soda should be added, and then excess of citric acid, both spectra being carefully observed; and finally sulphite of soda, which definitely shows whether or no there is any other color than one belonging to group C. Combining the results of the two sets of experiments, we may decide whether it belongs to groups A, B, or C, or is a mixture of any of them. If the substance is insoluble in water but soluble in alcohol, the same experiments should be made, only we must add the color dissolved in alcohol to as much water as can be used without making the solution turbid, and must remember how much the presence of alcohol may interfere with the action of some of the reagents.

Another portion of the neutral color should then be dissolved in as strong alcohol as will give a clear solution, and ammonia, benzoic acid, a little citric acid, and much of it, added one after the other; and all the spectra carefully observed, as well as any other facts which may present themselves.

By thus using three separate quantities of color, and adding reagents one after the other, we may obtain about a dozen spectra, which may differ from one another in important particulars, or in some few cases may be all alike. The experiments are so easily made, that the whole series of twelve spectra may be seen in the space of five minutes; and the total quantity of material need not in some cases be more than $\frac{1}{1000}$th of a grain. The facts thus learned may show that for particular practical purposes some different method could be employed with advantage, and that only one or two simple experiments are needed. For example, suspected blood-stains should be treated in an entirely different manner, as described in my paper on that subject;* and in examining dark-colored wines, in order to form some opinion of their age from the relative quantity of the color belonging to group C, gradually formed by the alteration of the original coloring-matter of the grape belonging to group B, it is only requisite to observe the effect of sulphite of soda after the addition of citric acid. It would, however, extend this paper beyond the limits I have prescribed to myself, if I were to enter into practical applications, and I shall therefore merely give a description of a convenient method of grouping the various colors.

* Quarterly Journal of Science, Vol. II. p. 205.

(To be continued.)

EDUCATIONAL

THE MAGIC LANTERN

AS A MEANS OF DEMONSTRATION.

UNDER the above caption, we do not mean to confine ourselves to a discussion of the action of the complete instrument named, but propose to include various important uses to which different parts of the apparatus can be applied, with certain additions and attachments. Among these, we shall, in the present case (postponing other matters of a less importance to future numbers), take up the arrangement of apparatus by which may be performed that beautiful experiment illustrating the total reflection of light at the interior surface of a dense body, and commonly designated as

THE LUMINOUS FOUNTAIN.

We believe that this experiment was first performed by Duboscq, and though often repeated and frequently alluded to in various publications, is generally regarded as presenting great difficulties in its reproduction. Our own experience has, however, shown us that it may not only be repeated with little cost and great ease by any one having the usual appliances of a gas lantern; but that it is an illustration of great beauty and interest, which would amply repay many times the trouble of its development.

Success, however, depends upon attention to a few particulars, which, to the best of our knowledge, have never been put on record, and we will therefore proceed to give a full description of the same.

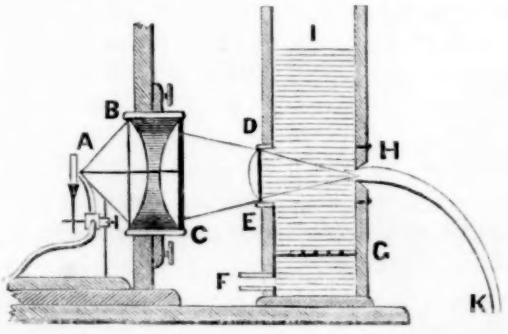
Desiring to arrange this illustration, and hearing that Mr. E. S. Ritchie, of Boston, had made very thorough and successful investigations as to its best adjustment, we wrote to him for information, and were furnished by him in the most liberal and amiable manner with full accounts of all essentials, by reason of which we had nothing to do but to put together a few parts as described, in order to secure at once complete success.

The important points, as described by Mr. Ritchie, and verified

in our own experience, are these: 1st. Avoidance of currents and commotion in the reservoir. 2d. The employment of a sharp edged diaphragm, very smoothly finished, as a jet.

The entire arrangement of parts is as follows:

Let A represent the line light in the lantern box, and B E the condensers attached to its front, the object glass, tube, &c. being removed. By this means a cone of light is projected upon D E, which represents a plano—convex lens of 3 to 4 inches diameter, and 6 to 7 inches focal length. This lens fits into a cell, against a ring of rubber, upon which it is pressed by a screw cap, so as to render the joint water-tight. The tank P G is made of wood or tin, about 18 inches in height, 5 or 6 inches in the direction D H, and about one foot transversely.



At H is attached a diaphragm, opening, or outlet, flush inside with the front of the tank, sharp edged, and beveling outwards. Near the bottom of the tank is a perforated shelf, or false bottom, E G, below which enters the inlet pipe, F. The shelf, E G, serves to distribute the inflowing water, and prevent violent currents.

Under these circumstances, the water supply being carried to F by a ¾-inch rubber hose from a hydrant, or like supply; is regulated so as to keep a steady level at I (which can be easily recognized by watching the point of contact of the jet, H K, with the basin or reservoir in which it is received), and the light is turned on in the lantern.

We then have the light from the condensers concentrated at H, and thence issuing with the vein of escaping water, from whose interior surface it is repeatedly reflected so as to follow down the entire length of the jet, which thus becomes brilliantly luminous, appearing as a stream of liquid light, or luminous water.

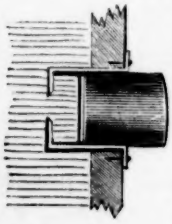
If the jet is then received in a large glass goblet, or vase, this also, as well as the drops and streams running over and from it, will gleam and glimmer in a beautiful manner. By placing a piece of colored glass in front of the condensers, B C, the stream of light will

be converted into a jet of liquid rubies, emeralds, or sapphires, according to the color employed.

If the supply is taken from an ordinary hydrant, the outlet, H, should not be more than 0·5 inch in diameter.

In starting and stopping, it is often desirable to close the outlet, H. To do this, with a cork directly applied, is at once awkward, and likely to injure the smoothness of the edge, which is so important to success. To obviate this difficulty, we propose the following plan:

Let the diaphragm be attached to the end of a short tube, running a little way into the tank, or projecting from it. A cork may then be used to close the outer end of this with ease, and without risk to the diaphragm.



In the experiments which we have made thus far, we have only employed jets of half an inch in diameter, and making streams of 7 to 8 feet in height; but Mr. Ritchie in some experiments made at Boston, with a view of public exhibition on the evening of the Fourth of July, produced successfully, jets of 15 to 20 feet, and 1½ inches in diameter, illuminating them with an electric light from 100 large Bunsen cells.

With regard to the arrangements used for this purpose, Mr. Ritchie tells me, that he carried the water from the street-pipe by fire-engine hose, first to a barrel (which being air-tight, served as an air chamber), thence to a long, erect, conical vessel, having five horizontal partitions pierced with numerous small holes to distribute the flow and avoid strong currents. The side of this vessel, in which the outlet was placed, was flat, and in this the sharp edged opening was fixed. The experiment with these arrangements proved perfectly successful, and was exceedingly beautiful if the air was calm, but the least wind ruffled the jet, and spoiled the effect. Prof. Pepper, as appears in his Play Book of Science, conducted with great success similar experiments in the Sydenham Crystal Palace, but in his description he omits to mention those points which are, as we find, essential to success. In the coming exhibition of the Franklin Institute, next Fall, we hope to develope this illustration on the grand scale.

KALICHROMATRY.

By Prof. Albert R. Leeds.

Some very pleasing effects may be obtained by superimposing the spectra from two bisulphide of carbon prisms upon the screen with two lanterns, arranged, as is usual, for dissolving views; one is to be pointed upward, through an angle of 64° 16′, the angle of minimum divergence—for a prism of 60° refracting angle—and the other is to be turned away from the screen, through the same number of degrees. Before the objective of the first, a prism is to be held, with its refracting angle upwards; before that of the second, another prism, with its refracting angle vertical. Glass plates, with a coating of blackened collodion or varnish having been prepared, the surface may be scratched away, so as to leave the glasses with one, two, or three horizontal bars, or the upper and lower quarter segments of a circle. These will be brought to a focus by Lantern No. 1, and will produce one, two, or three horizontal spectra, as the case may be. Corresponding glasses are to be prepared for Lantern No. 2, but with the bars vertical, or not differing therefrom by more than 45°. The width of the line should not exceed one-eighth of an inch. In this way the screen may be covered by a cross, or a grating of spectra, giving finely-contrasted tints, or circles, &c., may be formed. These expedients were resorted to, because the diacaustics produced by holding rods of glass, &c., in the path of a single decomposed beam were not satisfactory or brilliant.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, January 15th, 1868.

The meeting was called to order with the President, Mr. J. Vaughan Merrick, in the chair.

The minutes of the Board of Managers were reported by the Actuary.

Donations to the Library were received from the Society of Arts, London, and the Association for the Prevention of Steam Boiler Explosions, Manchester, England; la Société d'encouragement pour l'Industrie nationalle, l'Acdemie des Sciences, Paris, and la Société Industrielle, Mulhouse, France; der K. K. Geologischen, Reichanstalt, Vienna, Austria; Major L. A. Huguet-Latour, Montreal, Canada; Hon. Chas. O'Neill, M. C.; Prof. B. Pierce, Superintendent Coast Survey, The U. S. Observatory, Washington, D. C.; The Water Commissioners of Jersey City, N. J.; and from Messrs. S. S. White, Henry Vezin, and J. M. Maich, Philadelphia.

The Annual Report of the Board of Managers was then read.

The result of the election on that day was announced, and the following gentlemen were declared elected as officers of the ensuing year:—

For President, Mr. J. V. Merrick, for one year; for Vice-President, Prof. R. E. Rogers, for three years; for Treasurer, Mr. Frederick Fraley, for one year; for Secretary, Prof. Henry Morton, for one year; for Auditor, Mr. Wm. Biddle, for three years; for Board of Managers, William B. Le Van, Percival Roberts, Jacob Naylor, Samuel Sartain, O. H. Wilson, Charles Bullock, E. Longstreth, Enoch Lewis, for three years; Jacob G. Neaffie, for two years; J. H. Linville, for one year.

The paper announced for the evening, on Pneumatic Piles, was then read by the Hon. W. J. McAlpine, C. E.

The Secretary's report on Novelties in Science and the Mechanic Arts, was read, at the conclusion of which the meeting, on motion, adjourned.

HENRY MORTON, *Secretary.*

Bibliographical Notices.

Leaf Prints; or, Glimpses at Photography. By Charles F. Himes, Ph.D., Professor of Natural Science, Dickinson College, Carlisle, Pa. Philadelphia: Bennerman & Wilson, 1868.

This little book is one that attracts attention immediately by its very beautiful outward form, and gratifies equally by its literary and scientific worth. Professor Himes writes like a scholar and artist. He gives an interesting preface and an admirable introduction to his book, which all may read with pleasure and profit, and

then supplies rules and directions for working, so sound and simple, that success must attend the employment of the processes recommended.

The book teaches all lovers of leaf life a short and admirable method by which the most beautiful forms and true foliage may be perfectly reproduced and preserved. A little prepared paper and piece of glass and some sunshine enables any one to transfer to his or her album the graceful forms of any leaves or forms, or the exact patterns of prints, laces and embroideries. The results are so far in advance of any process heretofore employed in producing leaf pictures, that the book can hardly fail to secure a wide circulation. Considering the style in which it is "got up," it is also a very cheap publication.

Metals and Grains.—The Merchants' and Bankers' Almanac for 1868 contains, in addition to a list of 6000 banks and bankers in the United States, Europe, &c., contains the following statistics:

Monthly Prices for Forty Years, of Cotton, Wool, Pork, Flour, Wheat, Corn, Oats, Hops, Iron, Copper, Coal, Coffee, Molasses, Sugar, &c. IX. Annual Product of Wheat, Corn, Rye, Potatoes, in each State, 1866. X. List of New Publications on Banking, Finance, &c. XI. List of Banks, Bankers, Savings Banks, in Canada. XII. Daily Price of Gold, 1863–1867. XIII. Price of Consuls, Annually, 1750–1860. XIV. Fluctuations in 150 Stocks, Bonds, &c., 1867. XV. Progress of Railroads, 1834–1866. XVI. Clearing-House Statistics of New York and London. XVII. Prices of 80 Staple Articles, Monthly, 1869. XVIII. List of 2000 Cashiers. XIX. Prices, Monthly, of American Securities, London, 1867. XX. Engravings of New Bank Buildings. One volume, octavo, 240 pages. Price, $2. Issued at the *Bankers' Magazine* Office, N. Y.

Chemical Tables. By Stephen P. Sharples, S. B.: Sever & Francis.

We have a little book which requires and admits of but little criticism. A few words of description, and an abstract of its table of contents, will be its best recommendation to those whom it concerns. It is a volume of 192 pages, without the least attempt at beauty or elegance in its appearance, but for that reason the more fit to lie upon the laboratory table, and so be always at hand for reference whenever any numerical fact is required. It contains no ana-

lytical tables, such as Will's, but all numerical ones which migh by any chance be needed by the practical chemist, manufacturer, or analyst. It can, however, better speak for itself, as thus, in its table of contents: Elements—their equivalents, logarithms, atomic weights, formulæ, per cent. in compounds, factors for analysis, &c., &c. Specific gravities—of elements, of compounds, of important solutions, as ammonia, acids, &c., &c. Tables relating to heat—atomic, specific, and latent heat, expansion of all kinds of bodies, tension of various vapors at various temperatures, heat units evolved by combustion, barometric tables, &c., &c.

Tables relating to light—wave lengths—indices of refraction, &c.

French and English tables compared.

Table of logarithms. (This is but a brief abstract from the contents, which occupies nearly three pages.)

A Manual of Inorganic Chemistry, arranged to facilitate the Experimental Demonstration of the Facts and Principles of the Science. By C. W. Eliot, Professor of Analytical Chemistry and Metallurgy, and Frank H. Storer, Professor of General and Industrial Chemistry, in the Massachusetts Institute of Technology. New York: Ivison, Phinney, Blakeman & Co.

We have here an attempt to give simple and minute instructions in the conduct of experiments, after the example of Stöckhardt, to incorporate a large bulk of purely chemical knowledge, in the manner of Fownes, together with the most important applications of this knowledge, which the works of Miller, Ure, Muspratt, and Watts afford, and, finally, to adapt the explanations and nomenclature to the "new theory."

The authors have executed their task with much skill, labor, and exactness, and to persons not having access to a chemical library the work is particularly valuable. But with all this excellence we apprehend it will not take the place for which it was intended. The simple manipulations of Stöckhardt, which made his chemistry a favorite in ladies' schools and country academies, where the teacher was compelled to keep one hand upon the test-tube, and the other upon the test-book, are lost in a multitude of others, too difficult for the tyro to repeat, and too expensive and complex for the resources of most schools. It would be very gratifying, and we say so in all sincerity, if college students even would look upon such a thorough book with favor; but it is a deplorable certainty, we think,

that they would burn it to ashes with ecstatic delight, and regard its teacher as a just object of sophomoric hatred. Its use will probably be restricted to students who have chosen chemistry as a profession, and who are willing to follow instructions with laborious care. To special schools for chemistry, indeed, it is a great boon.

The experiments given exhibit the influence of the exact method of lecture-table demonstration introduced by Hoffman, whose Modern Chemistry will ever remain as a classic in chemical literature. Chapter XII., on ozone and antozone, has evidently been prepared with great pains, and is probably the best compilation accessible on the different methods of preparation, the tests and properties of these two allotropes. The appendix upon chemical manipulation, in which are included articles upon glass tubing, cutting and cracking glass, blowing bulbs, lamps, bellows, sand baths, pneumatic troughs, etc., gives the methods which the general employment of gas, india rubber, and other modern conveniences have brought into use.

Time and Tide.—Twenty-five Letters to a Working-man of Sunderland on the Laws of Work. By John Ruskin, LL.D., New York: Wiley & Son.

Like former works from their great author, this present short outburst of Ruskin, is able to make the reader pause, reflect, oppose many things vehemently, and end by effecting a certain change of opinion. It has originated in the deep-felt agitation which is spreading from the laboring classes outward through all ranks of English society. It professes to find a remedy for the terrible wrongs and injuries which have grown out of the unequal distribution of riches and land in England, by educating the poor man to make the best of his lot, the lords to the duty of self-denial and unselfishness. It exposes the miserable quality of what are styled amusements, to our contempt; the relative estimate (judged by the sums appropriated) which a Christian community appears to place on art and war, is laughed to scorn. The laws of demand and supply, of rent, etc., are estimated by the light of a wisdom strange to political economists—that of the Bible. Some will call the book Utopian, and its author a dreaming fanatic, but to such an Utopia the world is moving, and such dreamers push with sturdiest hands against the sluggish ball.

A COMPARISON *of some of the Meteorological Phenomena of* JANUARY, 1868, *with those of* JANUARY, 1867, *and of the same month for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11½′ W. from Greenwich. By PROFESSOR J. A. KIRKPATRICK, of the Central High School.

	January, 1868.	January, 1867.	January, for 17 years.
Therm ometer—Highest—degree.....	46·00	42·00	65·00
" date.....	2d.	5th.	29th, '64.
Warmest day—mean ..	42·00	37·00	58·33
" " date.....	2d. & 4th.	6th.	15th, '63.
Lowest—degree.....	11·00	9·00	—9·00
" date.....	10th.	16th.	8th, '66.
Coldest day—mean	18·67	16·00	—1·00
" " date	13th.	30th.	9th, '56.
Mean daily oscillation...	11·79	10·61	11·88
" " range.....	5·80	5·03	6·44
Means at 7 A. M.....	27·84	23·29	27·50
" 2 P. M.....	33·23	29·29	34·66
" 9 P. M.....	29·87	26·23	30·68
" for the month....	30 31	26·27	30·95
Barometer—Highest—inches.....	30 580	30·413	30·757
" date.....	31st.	3 th.	8th, '66.
Greatest mean daily pressure	30·531	30 407	3 .665
" " " date...	31st.	30th.	8th, '66.
Lowest—inches	29·291	29 337	28·911
" date.....	1st.	21st.	23d, '53.
Least mean daily pressure...	29·459	29·426	29·086
" " " date...	1st.	10th.	23d, '53.
Mean daily range.....	0·271	0·225	0·219
Means at 7 A. M	30 010	29·918	29·960
" 2 P. M	29·986	29·883	29·920
" 9 P. M	30·028	29 919	29·951
" for the month.....	30·008	29·907	29 944
Force of Vapor—Greatest—inches	0·247	0·183	0·505
" date	23d.	21st.	11th, '58.
Least—inches.....	·018	·042	·023
" date.....	9th.	30th.	22d, '57.
Means at 7 A. M.....	·129	·099	·131
" 2 P. M.....	·127	·109	·145
" 9 P. M.....	·135	·101	·141
" for the month...	·130	·103	·139
Relative Humidity—Greatest—per cent	95·0	94·0	100·0
" date.....	21st.	20th.	Often.
Least—per cent....	30·0	40·0	24·0
" date.....	24th.	5th.	25th, '60.
Means at 7 A. M....	80 6	76 3	79·5
" 2 P. M....	64·7	66·3	67·3
" 9 P. M....	77·8	68 7	76 0
" for the month	74·4	70·4	74·3
Clouds—Number of clear days*.....	9·	12·	9·1
" cloudy days	22·	19·	21·9
Means of sky covered at 7 A. M	57·7 per ct	52·9 per ct	61·9 per ct
" " " 2 P. M	60·3	60·0	62·3
" " " 9 P. M	52·2	42·9	48 7
" " for the month	56·7	51·9	57·6
Rain and melted snow—Amount—inches	3·49	1·925	3·176
No. of days on which rain or snow fell ...	13.	8·	10·5
Prevailing Winds—Times in 1000.....	N79°43′ w·265	N69° 9′ w·424	N62°58′ w·322

* Sky one-third or less covered at the hours of observation.

A COMPARISON *of some of the Meteorological Phenomena of* FEBRUARY, 1868, *with those of* FEBRUARY, 1867, *and of the same month for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 6.0 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75 °11½′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	February, 1868.	February, 1867.	February, for 17 years.
Thermometer—Highest—degree.	52·00	55 00	70 00
" date.	20th.	14th.	23d, '60.
Warmest day—mean	42·67	51·83	59·30
" " date	21st.	14th.	25th,'57.
Lowest—degree.	3·00	16·50	—1 00
" date.	23d.	11th.	7th'55;8th'61.
Coldest day—mean	12 83	24 33	4·50
" " date	23d.	10th.	6th, '55.
Mean daily oscillation	16·00	14·64	13 61
" " range	7·84	6·43	7·21
Means at 7 A. M.	21·72	35 84	29·32
" 2 P. M	31·21	43 36	38 30
" 9 P. M	26·72	40·66	33 61
" for the month	26·55	39·95	33·74
Barometer—Highest—inches	30 748	30·970	30·970
" date	1st.	11th.	11th,'67.
Greatest mean daily pressure	30·672	30·862	30 862
" " " date	23d.	11th.	11th, '67.
Lowest—inches	29·566	29·303	29·065
" date	6th.	3d.	23d, '53.
Least mean daily pressure.	29·633	29·398	29·227
" " " date	28th.	3d.	16th, '56.
Mean daily range	0·278	0·279	0·228
Means at 7 A. M	30 197	30·087	29·959
" 2 P. M	30·154	30 053	29 903
" 9 P. M	30·156	30·065	29·932
" for the month	30·169	30·068	29·928
Force of Vapor—Greatest—inches	0·231	0·361	0·549
" date.	21st.	14th.	16th, '57.
Least—inches	·038	·049	·013
" date	23d	10th.	6th, '55.
Means at 7 A. M	·100	·171	·138
" 2 P. M	·121	·174	·157
" 9 P. M	·121	·193	·157
" for the month	·114	·179	·151
Relative Humidity—Greatest—per cent.	95·0	95·0	100·0
" date	27th	2d & 20th.	Often.
Least—per cent.	42·0	27·0	20·0
" date	19th.	27th.	22, '64.
Means at 7 A. M.	80·0	76·8	78·5
" 2 P. M.	67·1	60·2	63·5
" 9 P. M.	79·5	72·7	75·1
" for the month.	75·6	69·9	72·4
Clouds—Number of clear days*.	11·	6·	8·5
" cloudy days.	18·	22·	19·7
Means of sky covered at 7 A. M	64·5 per ct	65·3 per ct	60·9 per ct
" " " 2 P. M	50 7	68·2	60·6
" " " 9 P. M	47·9	61·4	48·5
" " for the month	54·4	64·9	56·7
Rain and melted snow—Amount—inches	2 59	4 820	3·237
No. of days on which rain or snow fell	6·	12·	9·6
Prevailing Winds—Times in 1000.	s77°48′w·240	s73°30′w·181	s75°47 w·273

* Sky one-third or less covered at the hours of observation.